chapter 3

Safety

" There is need for a real emphasis on safety in all highway program funding. Safety should be a 'North Star' for every one. It cannot be just the direction for the USDOT."

Dr. Robert Scopatz
Kissimmee, Florida
2025 Visioning Session, Atlanta, GA, Mar. 13, 2000

"Seat belt use is just as important to transportation safety as vaccinations are to disease. We must look at seat belt use as a public health issue."

Dr. Marvin Liebovich
2025 Visioning Session, Apr. 20, 2000

chapter 3

Safety

The public embraced the need for higher levels of transportation safety in the late 1960s and early 1970s, creating a climate for new safety initiatives. Since then, the focus on safety within the U.S. Department of Transportation (USDOT) has progressively increased. Today, safety is the Department's "North Star." Working closely with other levels of government and the private sector, the USDOT is aggressively pursuing safety initiatives in all modes of transportation: highways, motor carriers (trucks and buses), transit, railroads, aviation, the maritime industry, and pipelines.

Over the last 25 years, many new transportation safety measures have been successfully implemented. Death and injury rates have been reduced on the roads, rails, and waters, as well as in the skies. In 1975, transportation-related incidents were the sixth leading cause of death in the United States, accounting for nearly 50,000 fatalities. By 1998, transportation-related incidents had become the eighth leading cause of death, accounting for nearly 44,000 fatalities (figure 3-1) in which 41,501 people died on the nation's roads, 667 in air crashes (none of these involved U.S. air carriers), and more than 1,500 were from other transportation-related incidents [USDOT BTS 1999]. Table 3-1 shows the detailed distribution of transportation-related fatalities for all modes in 1998, the latest year for which these numbers are available.

"Safety is President Clinton and Vice President Gore's highest transportation priority, and reaching this goal will benefit all. I call on you, the safety leadership of America, in partnership with the Department, to join us in a renewed effort to increase seat belt use and reduce catastrophic loss of lives on our highways."

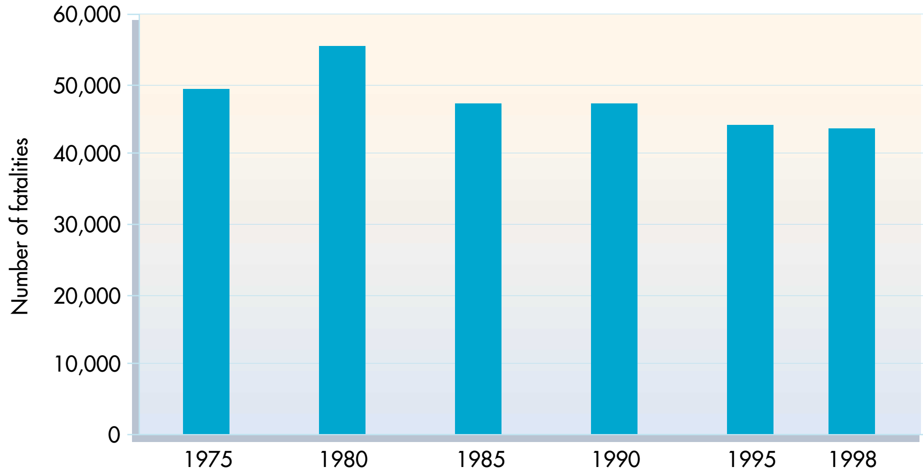
Rodney E. Slater,
Secretary, U.S. Department of Transportation
Mar. 13, 2000

This improvement in safety took place while travel across all modes of transportation increased substantially. The success of safety programs is especially visible on our highways. The fatality rate per 100 million vehicle miles traveled (VMT) for highway traffic crashes (which constitute more than 90 percent of all transportation-related fatalities annually) has been reduced by more than half. The fatality rate went from 3.4 in 1975 to 1.5 in 1999 (figure 3-2), while the VMT nearly doubled during the same period [USDOT NHTSA 2000].

USDOT has set specific targets for the next few years to improve transportation safety. These include President Clinton's goal to reduce child fatalities in highway traffic crashes by 25 percent by 2005, Vice President Gore's initiative to reduce the U.S. commercial air carrier fatal crash rate by 80 percent by 2007, and the USDOT's goals to reduce highway fatalities by 20 percent by 2008 and commercial truck-related fatalities by 50 percent by 2010. Specific rail safety [USDOT OST and FRA 1996], transit safety [USDOT FTA 2000], maritime safety [USDOT 1999], and pipeline safety [USDOT RSPA 2000a] initiatives also are in place.

Figure 3-1

Total Fatalities in All Modes of Transportation: 1975-98



Note: For 1975, 1980, and 1985, there may be some overlap in fatality numbers between various modes. The overlaps may affect 1 percent of data and would not impact the shape of the graphic. 1998 numbers are based on preliminary BTS estimates.
Sources: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1999* (Washington, DC: April 1999), Table 3-1, page 203.

Table 3-1

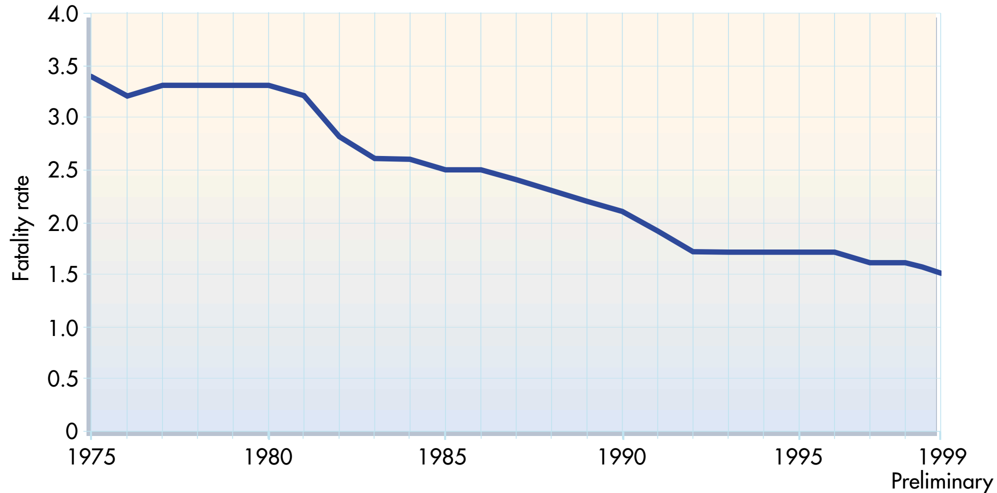
Transportation Fatalities by Mode: 1998 and 1999

Fatalities by mode	1998	1999
Highway	41,501	41,345
Percent change from previous year	-1.29	-0.30
Recreational Boating	813	773
Percent change from previous year	-0.97	-4.92
General Aviation	621	622
Percent change from previous year	-5.91	0.16
Railroad	577	530
Percent change from previous year	-4.15	-8.15
Highway-Rail Grade Crossing	431	402
Percent change from previous year	-6.51	-6.73
Transit (1997-1998)*	275	286
Percent change from previous year	4.17	4.00
Commercial Maritime Transportation**	107	154
Percent change from previous year	-30.52	43.93
Pipeline	18	26
Percent change from previous year	80.00	44.44

*1999 transit data are unavailable.
**1999 data are preliminary and subject to change as state and local jurisdictions close fatal accident cases.
Note: Summing the numbers in the table will not result in a correct count for all fatalities because some are double counted.
Sources: Data compiled from various government agencies as cited in the U.S. Department of Transporation, Bureau of Transportation Statistics, *National Transportation Statistics 1999*, table 3-1, available at http://www.bts.gov/ntda/nts/nts.html, and the U.S. Department of Transportation, *1999 Performance Report/2001 Performance Plan,* available at http://www.dot.gov/ost/ost_temp/. Preliminary highway data for 1999 are from the U.S. Department of Transportation, National Highway Traffic Safety Administration, personal communication, October 2000.

Figure 3-2

Motor Vehicle Crash Fatality Rate Per 100 Million Vehicle-Miles Traveled: 1975-99
(Annual rates)



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

As we start this new century, the United States has one of the safest transportation systems in the world. New strategies are being developed to continue the success of the last quarter century as the returns from past programs near saturation. In the decades to come, we will strive to make our transportation system even safer by being visionary and vigilant and by using new technology that complements laws, regulations, and enforcement measures.

Human error is a leading contributor to transportation-related safety problems, and research in understanding the human factors appears to be one of the key areas for future emphasis. The National Science and Technology Council's National Transportation Science and Technology Strategy highlights human performance and behavior as one of the research areas that could dramatically transform transportation in the coming years. The USDOT, through its multimodal Human Performance Coordination Committee, has set specific goals and is leading the effort to make the transportation system safer by promoting research and development in this field (box 3-1).

In March 1999, the USDOT hosted the first-ever National Transportation Safety Conference and brought together the entire transportation safety community across all transportation modes. At this conference, the safety community adopted the motto "safety is a promise we make and keep together" and identified 10 top goals and objectives that led to the creation of a National Safety Action Plan. These action goals are held together by a collaborative leadership effort to mobilize the public and private sectors to:

1. promote and require use of safety equipment in all transportation modes,
2. promote a culture of safety for all transportation modes and the population,
3. increase research of performance factors across all transportation modes,
4. adopt a federal uniform law of 0.08 percent blood alcohol concentration for drivers and a zero tolerance level for truckers,
5. increase funding to support enforcement of existing transportation laws and regulations,
6. maximize existing safety partnerships,

7. do a better job of data collection and reporting across all jurisdictions,
8. implement fatigue management practices,
9. increase use of technology to improve safety in all transportation modes, and
10. improve international safety cooperation.

Since the conference, this collaborative effort has yielded key improvements in addressing safety. In October 2000, President Clinton signed into law a national impaired driving standard of 0.08 blood alcohol concentration. This will reduce drunk driving on the nation's roads and save lives. Together we have taken steps to improve transportation safety data for strategic and operational decision, to develop and use advanced safety technologies, and to fund the enforcement of transportation-related laws and regulations. In addition to the top 10 goals, the USDOT has major programs to address human-performance related safety issues.

Box 3-1

Human Performance Factors

Human performance-related problems play a significant role in the safety of U.S. transportation systems. Because 70 to 90 percent of transportation crashes involve human error, reducing or mitigating these human errors can have a significant impact on associated human, environmental, and financial costs.

The USDOT has established a multimodal Human Factors Coordinating Committee (HFCC) as the focal point for human factors issues within the Department. The HFCC's responsibilities include developing and implementing a national strategic agenda for human factors research in transportation and serving as a human factors information resource to the transportation community. The HFCC facilitates the implementation of human factors elements of the USDOT Strategic Plan and supports the activities of the USDOT Research and Technology Coordinating Council as well as the National Science and Technology Council's Committee on Technology and its Subcommittee on Transportation R&D.

"We need to employ human factors expertise in the design, development, evaluation and use of transportation technologies and systems to ensure that we do not exceed the limits of human performance, and that we use the full capabilities of the human. We compromise the capabilities of technologies when we fail to consider human performance issues associated with their use. We need transportation systems that adapt to humans instead of humans adapting to them."

Rodney E. Slater
Secretary, U.S. Department of Transportation
Human-Centered Systems: The Next Challenge in Transportation, June 1999.

A heightened awareness of the role of human performance and behavior issues in transportation safety is occurring at a time when a variety of new technologies are being developed and introduced into transportation systems to enhance their capabilities. The major areas of human factors-related concerns associated with transportation systems include:

- fatigue and workload,
- hours of service,
- training and certification,
- automation,
- passenger security,
- aging and mobility,
- information overload,
- substance abuse, and
- adequate staffing.

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Box 3-1 ***continued***

The USDOT human factors coordinated program is integrated and synergistic and incorporates the following elements:

- **modal specific** — each mode will continue to conduct focused, applied programs designed to support their unique needs.
- **cross-modal** — new initiatives will sponsor broadly applicable projects that complement the modal programs and can be tailored for use by the modes.
- **interagency** — all of the USDOT's human factors research programs will leverage the resources of other federal agencies.

The human factors research program supports long-term national transportation goals to:

- ensure safer, more efficient, and more productive transportation products and services;
- provide reliable, safe, dependable transportation systems that will enable efficient U.S. industries to achieve or maintain world-class competitiveness;
- improve the integration of national transportation resources to provide "seamless" transportation to customers using multiple modes; and
- provide mobility for diverse populations and ensure the accessibility of transportation technologies and services.

Within the broad framework of human-factors research, each of the modal agencies have their own programs. The Federal Aviation Administration human factors program conducts research to support the development and implementation of equipment, training, and procedures that enhance the safety and efficiency of National Airspace System operations. The U.S. Coast Guard plan focuses on safety issues and organizational design. At the Maritime Administration, the focus is on productivity and competitiveness through safe, pollution-free construction and operations. The Federal Highway Administration, Federal Motor Carrier Safety Administration, and the National Highway Traffic Safety Administration focus on regulation, achievement of crash and injury reduction, and improved mobility for all citizens. The Federal Transit Administration is focusing on education for both transit agency managers and employees on the dangers and long-term expense and consequences of fatigue. The Federal Railway Administration program conducts research on railroad operating practices, railroad system design, and grade crossings to improve the overall safety of railroad operations, with a particular emphasis on reducing railroad employee fatigue.

Some representative systems being developed as a part of this research effort are collision avoidance systems, development and application of technology to measure driver fitness, fatigue research, an intelligent vehicle initiative, flight deck human factors, designs to accommodate aging drivers, and implementation of piloting navigation aids.

Projects under the various human factors initiatives are conducted in partnership with other federal agencies such as the Department of Defense and the National Aeronautics and Space Administration, as well as, where appropriate, with academia and industry. The key is to conduct research that will lead to a transportation system that adapts to the human, as opposed to the current system that requires the human to adapt to it. By working together, federal agencies and nongovernmental organizations can enjoy the synergy and economies of scale that make the most effective use of research and development efforts in the pursuit of answers to the nation's most pressing transportation safety and efficiency problems.

continued on next page

Box 3-1 *continued*

The USDOT human factors research initiative is developing advanced technologies to mitigate human error and upgrade skills specifically for new operators and older individuals through the application of advanced instructional technology. The overall goal of this initiative is to reduce transportation incidents by as much as one-third by the year 2020 by focusing on two critical areas:

- managing operator fatigue to sustain alertness; and
- upgrading operator abilities and skills, especially those related to recognizing and responding to imminent crash threats.

Specifically, the key elements of the coordinated program are two new multiagency human performance and behavior initiatives relating to fatigue detection and alertness enhancement—the Operator Fatigue Management (OFM) Initiative and Advanced Instructional Technology (AIT) Initiative. The strategic goal of the OFM is to reduce the economic impact from fatigue-related transportation injuries, fatalities, and property and environmental damage or loss by one-third within 20 years of the implementation and application of OFM findings, products, practices, and systems. The desired outcome of the AIT is to reduce the rate of motor vehicle crashes, deaths, and injuries among operators who participate by 33 percent within 20 years. This will be accomplished by using AIT techniques to enhance vehicle operator skills, decisionmaking, and safety-related attitudes.

Attention to human-centered technologies in transportation will contribute to U.S. leadership in transportation products and services. Currently, the United States is a leader in systems integration technologies, which will be key to achieving a competitive edge in the future. By linking our strength in systems integration to human performance, the "human-centered systems" concept will contribute to the commercial success of U.S. transportation systems.

Highway Safety

"One of the most successful governmental efforts to protect the public is in the area of auto safety. Hundreds of thousands of lives have been saved, thanks to laws requiring safety features such as bumpers, seatbelts, and airbags."

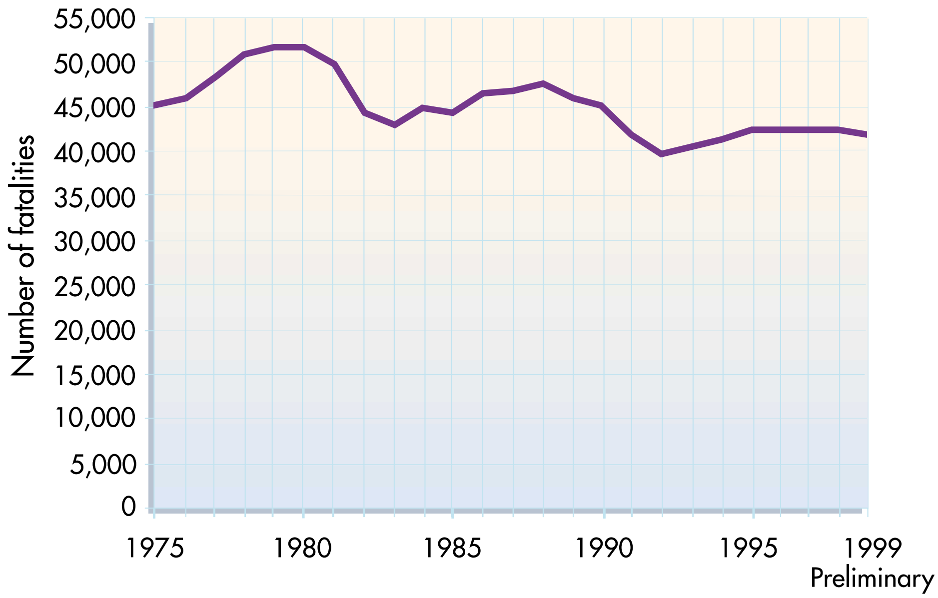
President William J. Clinton
Radio Address to the Nation
Feb. 27, 1999

When National Transportation Trends and Choices was issued in 1977, the legislative framework and funding for highway safety improvement programs had already been initiated by passage of the Highway Safety Acts of 1966, 1970, and 1973. The 1970 Act also established a new agency: the National Highway Traffic Safety Administration (NHTSA) under the USDOT, which along with other USDOT administrations (Federal Highway Administration, the new Federal Motor Carrier Safety Administration, Federal Transit Administration, and Federal Railroad Administration) provides leadership in promoting highway safety. In the last 25 years, new programs have been developed and safety on our nation's highways has improved owing to a combination of efforts by government regulatory agencies, the transportation research community, vehicle manufacturers, law enforcement agencies, and the public.

NHTSA's preliminary estimates show that 41,345 people were killed in highway crashes in 1999—3,180 fewer than in 1975 (figure 3-3). Figure 3-4 provides a comparison of fatalities by state for 1975 and 1998. The reduction in fatality rate per 100 million VMT (as shown in figure 3-2) since 1975 saved an estimated 46,000 lives in 1998 alone, and an estimated 479,000 lives since 1975 (figure 3-5).

Figure 3-3

Motor Vehicle Crash Fatalities: 1975-98 (Annual totals)



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Although highway crash fatality rates have declined, new strategies are being developed to provide even further reductions. In this context, some of the major issues that need to be addressed within the broad framework of improving highway safety include:

1. crash characteristics (single-vehicle run-off-the-road crashes, vehicle rollover and size compatibility in multivehicle collisions, and pedestrian and bicyclist fatalities);

2. behavioral characteristics (impaired driving; speeding; aggressive driving; driver fatigue; and use of safety belts, child restraints, and motorcycle helmets);

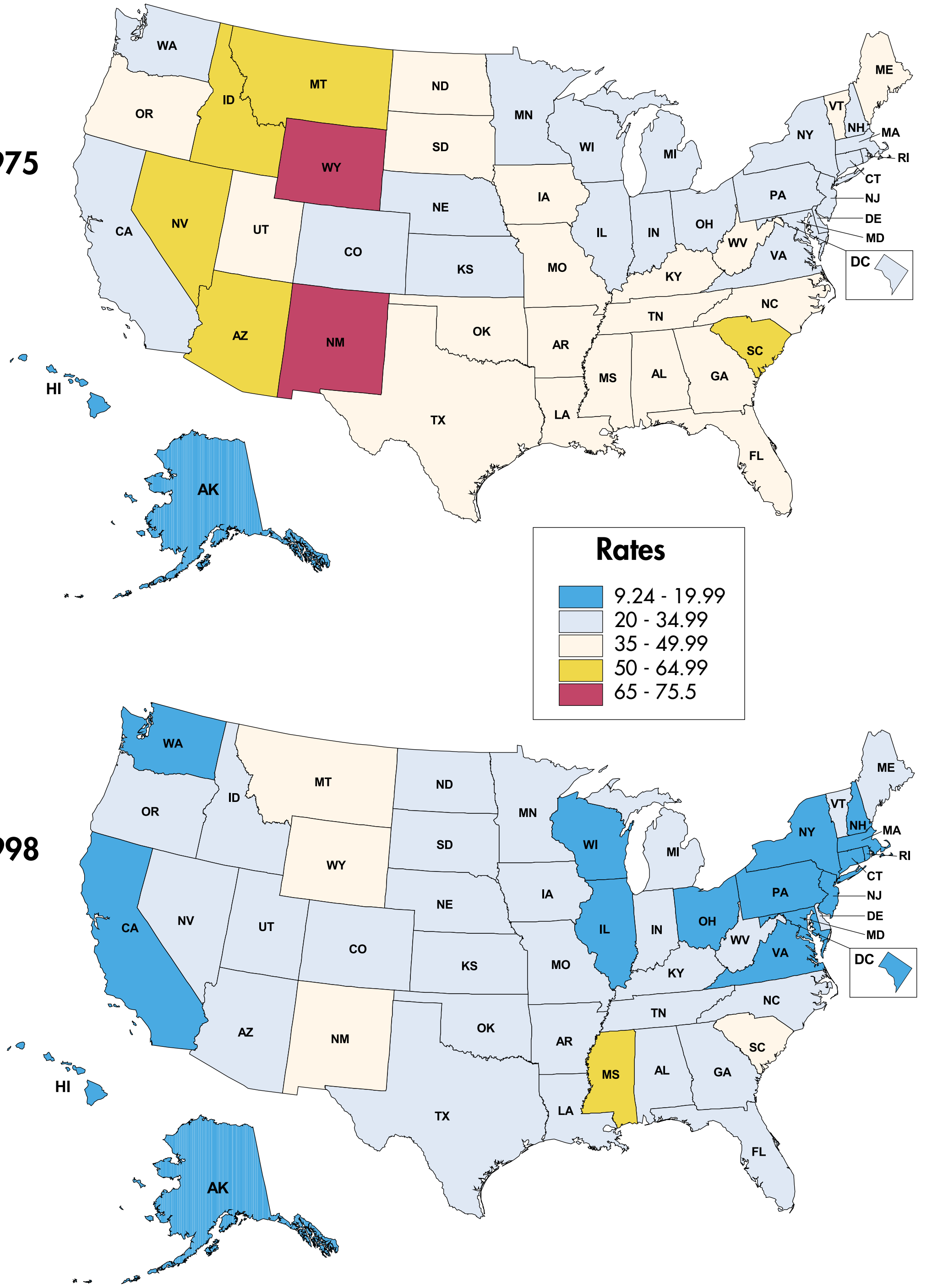
3. demographic characteristics (younger and older drivers);

4. vehicle safety characteristics (vehicle crashworthiness, crash avoidance standards, and air bags); and

5. road characteristics (highway speed limits and safer roads).

Figure 3-4

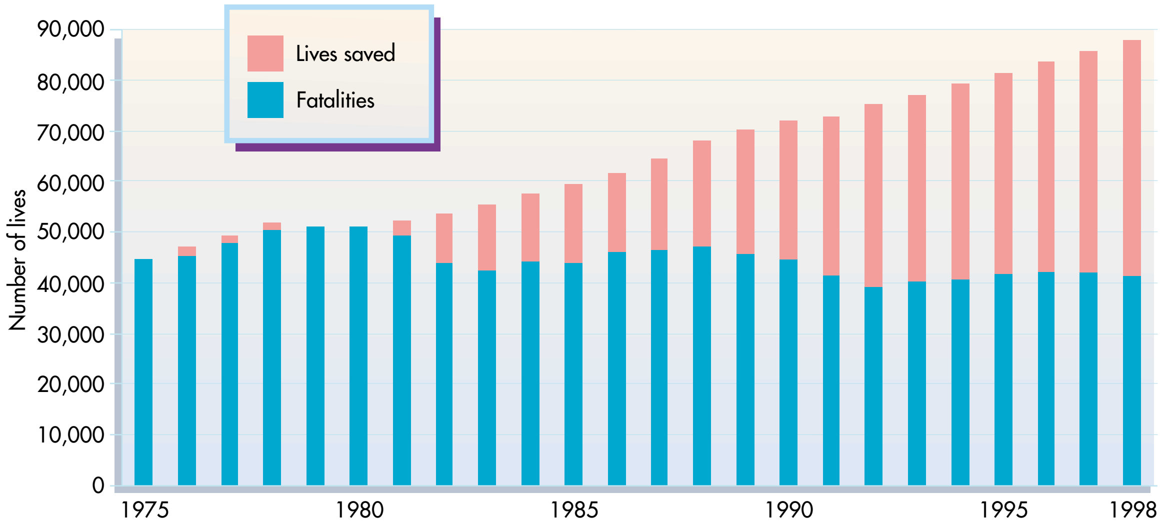
Total Traffic Fatalities: 1975 and 1998



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Figure 3-5

Highway Fatalities and Estimated Lives Saved (based on 1975 fatality rate per 100 million VMT): 1975-98



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999); U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (Washington, DC: Various years).

Crash Characteristics

Single-Vehicle Run-Off-the-Road Crashes: In 1998, 40 percent of traffic crash fatalities were vehicle occupants (including drivers) killed in single-vehicle crashes (table 3-2). This includes approximately 15,000 people who are killed each year as a result of run-off-the-road collisions with fixed objects, such as trees, embankments, guardrails, and utility poles. According to NHTSA, between 1974 and 1994, as many as 28 percent of all highway traffic fatalities can be attributed to crashes with fixed objects [USDOT NHTSA 1998d]. In rural areas, these crashes accounted for 66 percent of all traffic fatalities [USDOT FHWA 2000a]. Key factors in these collisions included driving errors associated with inattention, excessive speeding, and evasive maneuvers.

Table 3-2

Total Fatalities in Motor Vehicle Crashes by Type of Crash: 1998

Drivers/occupants killed in single-vehicle crashes	16,671
Drivers/occupants killed in two-vehicle crashes	15,724
Drivers/occupants killed in more than two-vehicle crashes	2,964
Pedestrians killed in single-vehicle crashes	4,795
Bicyclists killed in single-vehicle crashes	737
Pedestrians/bicyclists killed in multiple-vehicle crashes	449
Others/unknown	131
Total	**41,471**

Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Improvements in freeway ramp and curve designs, use of "rumble strips," state-of-the-art road features, (i.e., breakaway devices, barriers, and crash cushions), highly visible reflective signs and markings, and variable message signs are being used to reduce the numbers of these crashes and their severity. Several advanced technologies (discussed later in box 3-6), such as night vision enhancement and driver drowsiness detection systems might also be valuable in reducing single-vehicle crashes and fatalities.

Vehicle Rollover and Size Compatibility Issues: Since the early 1980s, the category of vehicles referred to as light trucks and vans (LTVs) has grown dramatically. The vehicles in this category include pickup trucks, vans, minivans, truck-based station wagons, and sport utility vehicles (SUVs). New LTV sales are growing at a compound annual growth rate of 8 percent, while the overall vehicle fleet is growing at a rate of 2 percent. These popular vehicles now represent 34 percent of the total fleet on U.S. highways [USDOT NHTSA 1998c].

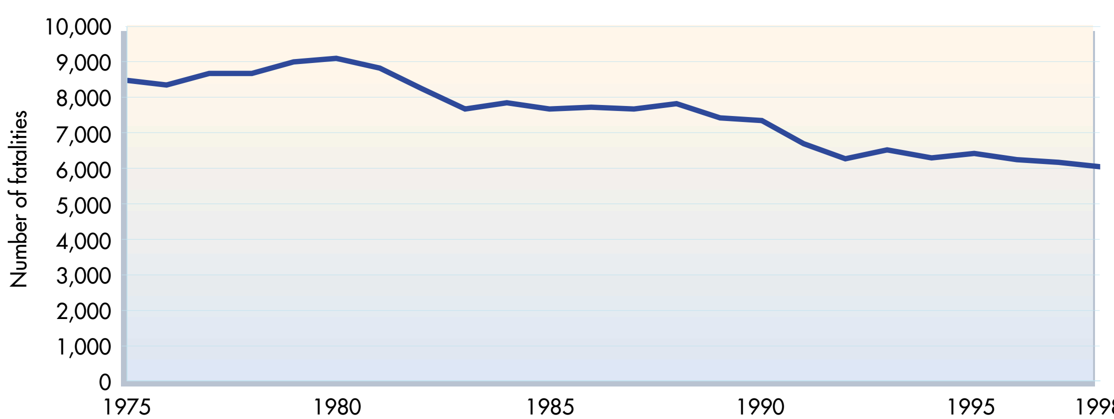
There are two characteristics of LTVs that can cause fatalities in traffic crashes: propensity to roll over and size compatibility. For example, SUVs are twice as likely to roll over as passenger cars, increasing the likelihood of occupant ejection and fatal injury. This contributes to the average rate of 98 rollover fatalities per million registered vehicles for SUVs compared to 47 such fatalities per million registered vehicles for all vehicle types.

Compatibility issues involve differences in vehicle size, weight, and geometry in multivehicle crashes, which can put occupants of cars at greater risk in an LTV-car crash than in a crash involving two or more cars. For example, research at the University of Michigan Transportation Research Institute shows that when an SUV strikes a passenger car in a frontal crash, occupants of the car are five times as likely to have fatal injuries as the occupants of the SUV; in cars that suffer side impacts, fatalities are 30 times higher for car occupants [USDOT NHTSA 1998c].

Pedestrian and Bicyclist Safety: Pedestrian and bicyclist fatalities in motor vehicle-related crashes declined between 1975 and 1998 from a combined total of more than 8,500 to about 6,000 each year (figure 3-6 and box 3-1). Ninety percent of these fatalities were pedestrians. In fact, more pedestrians are killed each year than the combined fatalities from air, sea, and train incidents. In 1998, approximately 5,220 pedestrians were killed and 77,000 injured in traffic crashes [USDOT NHTSA 1999b]. In the same year, there were 761 bicyclist fatalities. Table 3-3 lists some of the major factors involved in pedestrian fatalities in 1998, and table 3-4 lists major factors involved in bicyclist fatalities.

Figure 3-6

Pedestrian and Bicyclist Fatalities in Motor Vehicle Crashes: 1975-98



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Table 3-3

Factors in Pedestrian Fatalities: 1998

Factors	Number	Percent
Walking, playing, working, etc., in roadway	1,589	30.4
Improper crossing of roadway or intersection	1,517	29.1
Failure to yield right-of-way	709	13.6
Darting or running into road	649	12.4
Not visible	414	7.9
Inattentive (talking, eating, etc.)	131	2.5
Physical impairment	70	1.3
Failure to obey traffic signs, signals, or officer	67	1.3
Emotional (e.g., depressed, angry, disturbed)	25	0.5
Getting on/off/in/out of transport vehicle	22	0.4
Blackout	12	0.2
Nonmotorist pushing vehicle	8	0.2
Other causes	106	2.0
None reported	1,271	24.3
Unknown	105	2.0
Total	**5,220**	**100**

Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Table 3-4

Factors in Bicyclist Fatalities: 1998

Factors	Number	Percent
Riding, playing, etc., in roadway	167	21.9
Failure to yield right of way	163	21.4
Improper crossing of roadway or intersection	89	11.7
Failure to obey (e.g., signs, control devices, officers)	47	6.2
Operating without required equipment	38	5.0
Erratic, reckless, careless, or negligent operation	36	4.7
Not visible	32	4.2
Failure to keep in proper lane or running off road	29	3.8
Making improper turn	27	3.5
Inattentive (talking, eating, etc.)	25	3.3
Driving on wrong side of road	16	2.1
Failing to have lights on when required	15	2.0
Improper entry/exit from trafficway	11	1.4
Improper lane change	10	1.3
Other factors	74	9.7
None reported	216	28.4
Unknown	12	1.6
Total	**761**	**100**

Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Box 3-2

Pedestrian and Bicycle Trips

According to the Nationwide Personal Transportation Survey (NPTS), walking trips declined from 9.3 percent to 5.5 percent of all personal trips between 1977 and 1995, while bicycle trips increased from 0.6 percent to 0.9 percent during the same period [Pickrell & Schimek 1997]. Assuming the average trip length for pedestrians has remained the same, risk to pedestrians may not have actually decreased.

Pedestrians aged 25 to 44 suffered the highest number of fatalities, while for bicyclists, those 10 to 15 years old were the most vulnerable [USDOT NHTSA 1999b]. One significant factor in pedestrian and bicyclist fatalities is time of day—most pedestrian and bicyclist fatalities occur between 6:00 PM and 9:00 PM when visibility is low [USDOT NHTSA 1999b].

The Transportation Equity Act for the 21st Century (TEA-21) enhances integration and project funding for pedestrian and bicycle safety. It also requires states and metropolitan planning organizations to include bicyclists and pedestrians in their long-range transportation plans.

Behavioral Characteristics

Impaired Driving: Alcohol-related death rates were not compiled prior to 1982. That year, alcohol (Blood Alcohol Concentration (BAC) $\geq$ 0.01) was involved in 57 percent of all highway-related fatalities (figure 3-7). By 1999, this number dropped to 38 percent. In actual numbers, 15,794 people died in alcohol-related crashes in 1999 [USDOT 2000], compared to 25,165 such deaths in 1982 [USDOT NHTSA 1999a].

Improved state and local education programs; stiffer enforcement, including adoption of the .08 blood alcohol content law by 18 states (figure 3-8); higher minimum drinking age; and reduced tolerance for drinking and driving all have been major factors in reducing alcohol-related deaths[1]. However, alcohol is still the single largest factor in highway-related traffic fatalities. See figure 3-9 for alcohol-related crash fatalities by state in 1992 and 1998.

Also, in 1998, 18 percent of passenger car drivers, 20 percent of LTV operators, 1 percent of large truck operators, and 31 percent of motorcycle operators involved in fatal crashes were legally intoxicated (BAC equal to or greater than 0.10) [USDOT NHTSA 1999a]. Alcohol intoxication also poses a safety risk to pedestrians (see box 3-2).

Box 3-3

Alcohol Intoxication and Pedestrian Fatalities

In 1998, of the total number of pedestrians (14 years of age or older) killed in crashes, 33 percent were intoxicated. Also, of the total number of pedestrians killed in traffic crashes, 46 percent died in alcohol-related crashes where either the driver of the vehicle or the pedestrian, or both, were under the influence of alcohol.

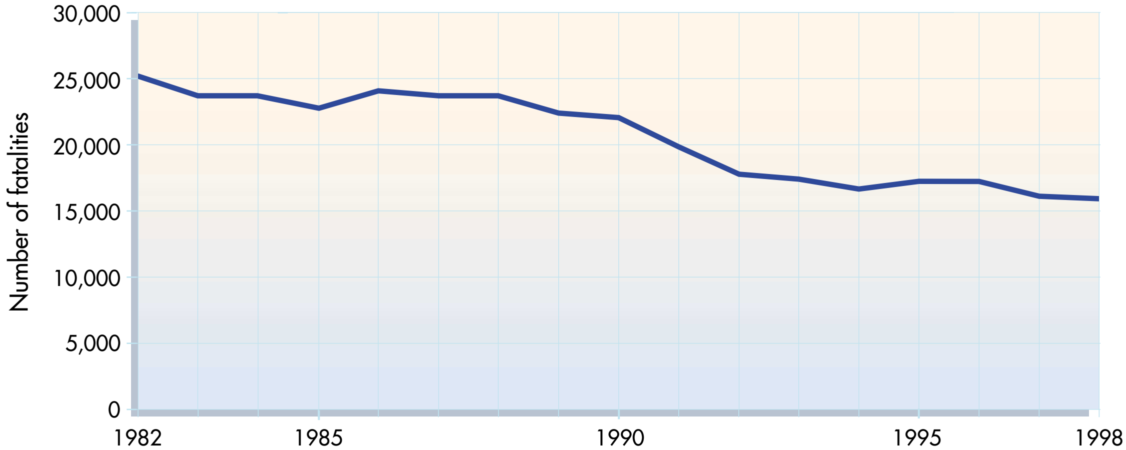
Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998,* DOT HS 808 956, available at http://www.nhtsa.dot.gov/people/ncsa/pdf/Overview98.pdf, as of July 7, 2000.

By age group, 21- to 34-year-olds comprised the highest percentage of intoxicated drivers involved in fatal crashes (figure 3-10). In 1975, the minimum drinking age for all alcoholic beverages was less than 21 years of age in 26 states (figure 3-11), and in 11 others, beer and wine could be bought at age 18. Such variations created "blood borders" as teenagers drove to neighboring states to drink and then attempted to drive home intoxicated.

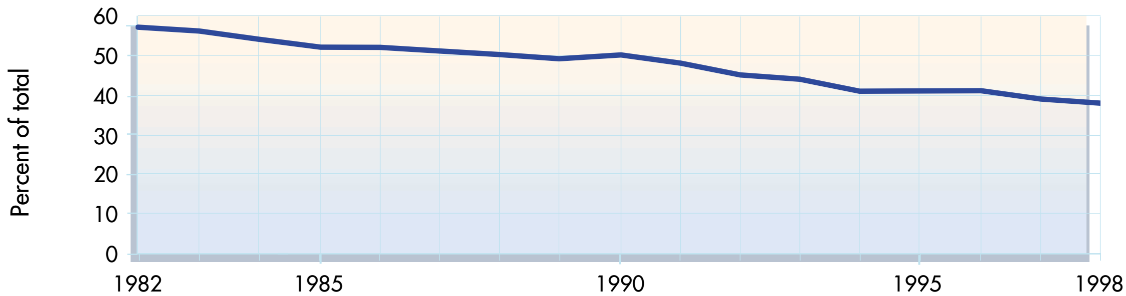
[1] Any state that does not adopt a BAC of 0.08 by year 2004 will lose a portion of federal highway funds—2 percent in 2004, 4 percent in 2005, 6 percent in 2006, and 8 percent in 2007.

Figure 3-7

Alcohol-Related Fatalities in Motor Vehicle Crashes: 1982-98 (Annual totals)



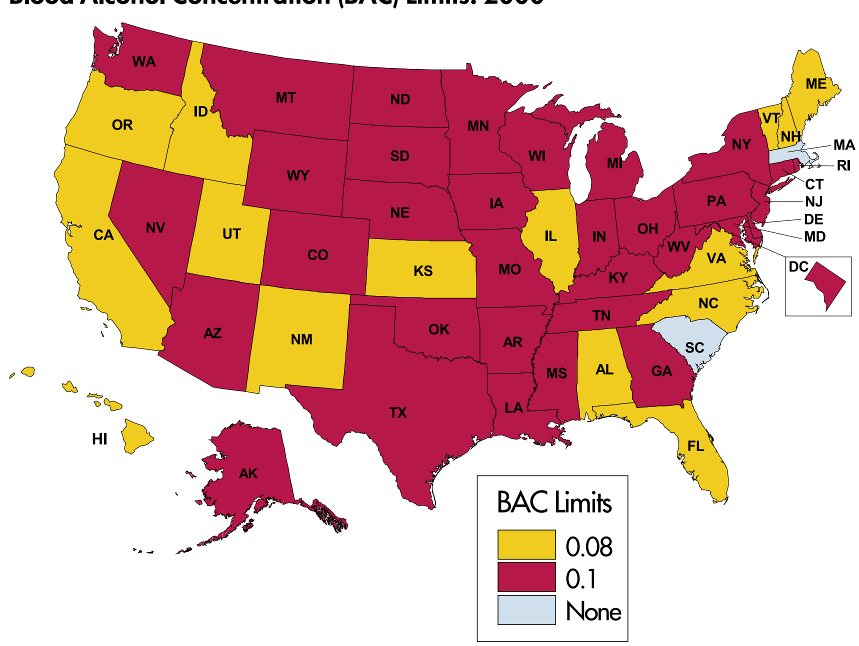
Alcohol-Related Fatalities as a Proportion of all Motor Vehicle Crash Fatalities



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Figure 3-8

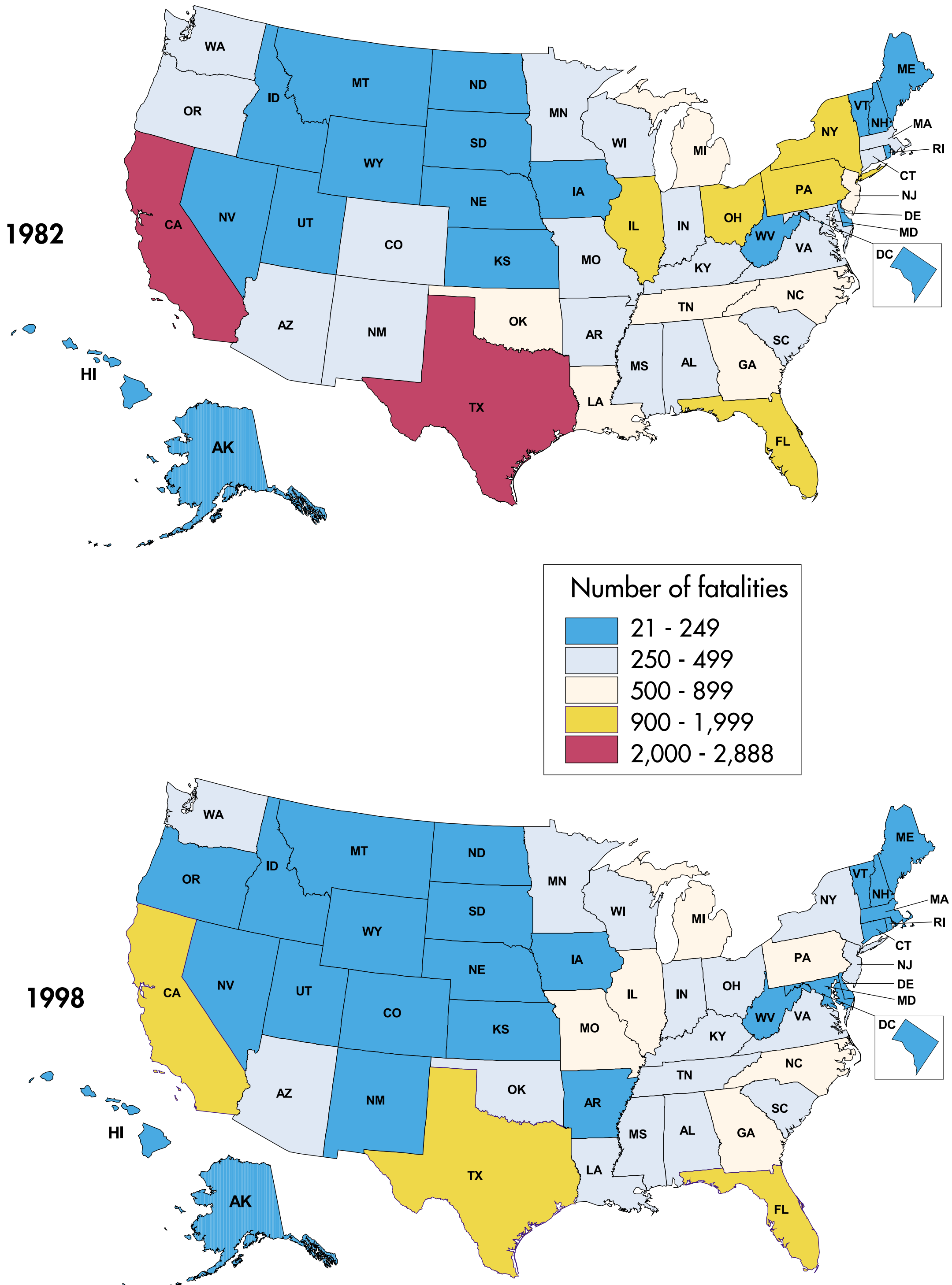
Blood Alcohol Concentration (BAC) Limits: 2000



Source: U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration (NHTSA), *Digest of State Alcohol-Related Safety Legislation* (Washington, DC); and USDOT, NHTSA, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Figure 3-9

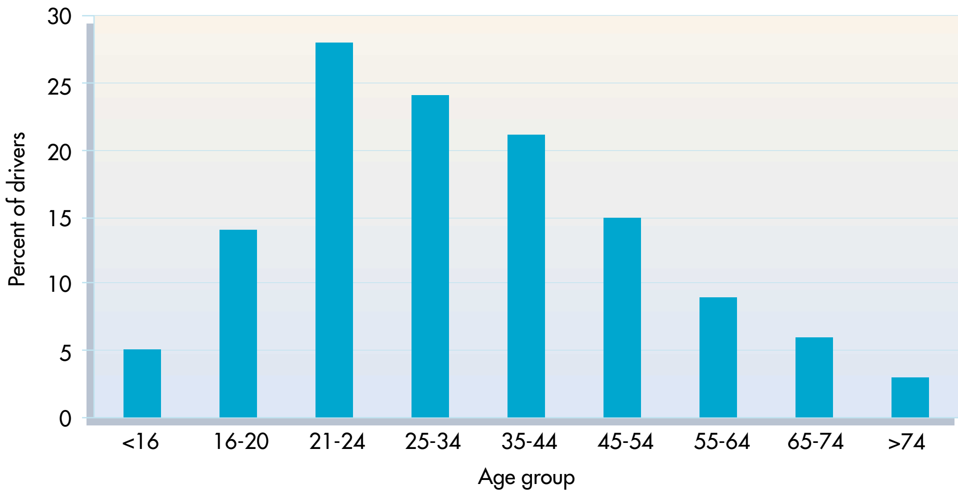
Alcohol-Related Traffic Fatalities: 1982 and 1998



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts* (Washington, DC: 1982 and 1999).

Figure 3-10

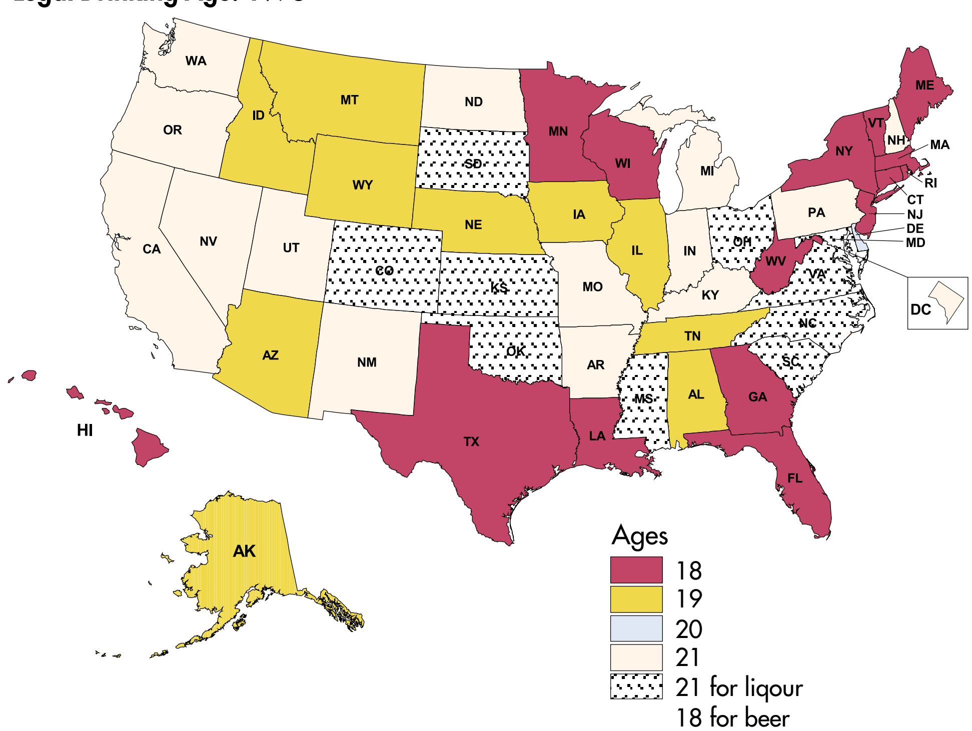
Drivers in Fatal Crashes with a Blood Alcohol Concentration of ≥0.10, by Age: 1998



Note: National Highway Traffic Safety Administration (NHTSA) estimates alcohol involvement when alcohol test results are unknown.
Source: U.S. Department of Transportation, NHTSA, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Figure 3-11

Legal Drinking Age: 1975



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Alcohol and Highway Safety Laws: A National Overview* (Washington, DC: 1979).

Under TEA-21, some portion of federal highway funding was restricted until states adopted a statute that not only prevented drivers under the age of 21 from obtaining alcoholic beverages, but also prevented persons of any age from making alcoholic beverages available to those under 21 [23 CFR Part 1313]. As a result, today, all 50 states and the District of Columbia have set the minimum drinking age at 21. NHTSA estimates that laws raising the minimum age for drinking have altogether saved 18,220 lives since 1975 [USDOT NHTSA 1998a].

Speeding and Aggressive Driving: Speeding—exceeding the posted speed limit or driving too fast for conditions—is one of the most pervasive factors contributing to traffic crashes. Speeding is a factor in 33 percent of all fatal crashes, and this percentage has remained consistent from 1993 to 1998 [USDOT NHTSA 1999c].

In 1998, 12,477 lives were lost in crashes where speeding was cited as a factor; the economic cost to society of these crashes was estimated by NHTSA to be $27.7 billion [USDOT NHTSA 1999c]. Collector and local roads have the highest speed-related fatality rates, both in urban and rural areas, while Interstate highways have the lowest speeding fatality rates. There also is a strong link between alcohol intoxication and speeding; 47 percent of speeding drivers between 21 and 24 years of age involved in fatal crashes were alcohol impaired [USDOT NHTSA 1999c].

Aggressive driving—when individuals commit a combination of moving traffic offenses that endanger other persons or property—became a safety issue in the 1990s, and it threatens to become a major public safety concern for the motoring public and law enforcement agencies in the 21st century. Some behaviors typically associated with aggressive driving include exceeding the posted speed limit, following too closely, making erratic or unsafe lane changes, improperly signaling lane changes, and failing to obey traffic control devices (e.g., stop signs, yield signs, traffic signals, and railroad grade cross signals). NHTSA calls the act of running a red light one of the most dangerous forms of aggressive driving. Increasing travel times due to congestion on our roads, especially in large cities, is considered to be one of the major triggers of this type of behavior. Exact numbers on fatalities and injuries caused by aggressive driving are not available at this time, but NHTSA is working toward collecting this information [USDOT NHTSA 1998b].

Driver Fatigue: In recent years, driver fatigue and drowsiness may have been a factor in 56,000 crashes annually, resulting in 1,550 fatalities and 40,000 injuries a year [USDOT NHTSA 1998e]. The causes of driver fatigue have been attributed to certain sleep disorders (sleep apnea, insomnia, narcolepsy) or just lack of sufficient rest. NHTSA is undertaking public education campaigns targeted at high-risk groups to reduce these types of crashes. FHWA and NHTSA also are cooperating in laboratory and field research to study driver drowsiness detection devices in vehicles, which can alert drivers to impending crash situations (see box 3-7, Advanced Vehicle Safety and Control Systems).

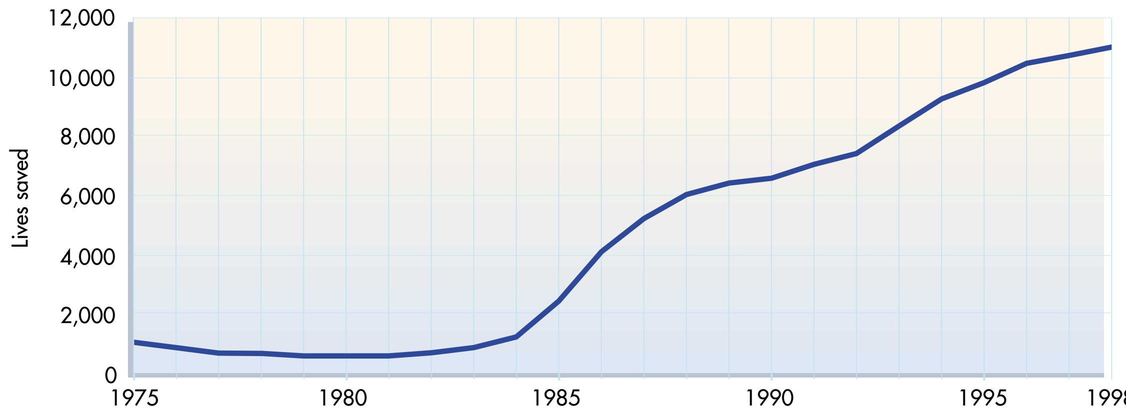
USDOT, NHTSA

Safety Belt Use: Safety belt use is the most important measure vehicle occupants can take to protect themselves in the event of a crash. When used, safety belts reduce the risk of fatal injury to front-seat passenger car occupants by 45 percent. For light truck occupants, safety belts reduce the risk of fatal injury by 60 percent [USDOT NHTSA 1998e]. From 1975 to 1998, as many as 112,000 lives may have been saved through the use of safety belts, including 11,000 in 1998 alone [USDOT NHTSA 1999b] (figure 3-12).

Use rates are not available for 1975, but 1982 surveys found that only 11 percent of vehicle occupants used safety belts [USDOT NHTSA 1983]. Today, the reported safety belt use rate is 79 percent in the 14 states and the District of Columbia with primary enforcement laws and 62 percent in the 36 states with secondary enforcement laws [NSC 1999]. Primary enforcement laws permit law enforcement officers to stop a vehicle and write a citation whenever they observe a violation of the safety belt law; secondary enforcement allows a citation to be given only after a vehicle is stopped for another traffic violation [NSC 1999]. The USDOT has been carrying out mobilization efforts in collaboration with nongovernmental organizations to encourage the use of seat belts. As a part of this effort, in November 2000, Mothers Against Drunk Driving became involved in the Operation ABC Mobilization: America Buckles Up Children. Figure 3-13 shows current seat belt use laws in each state.

Figure 3-12

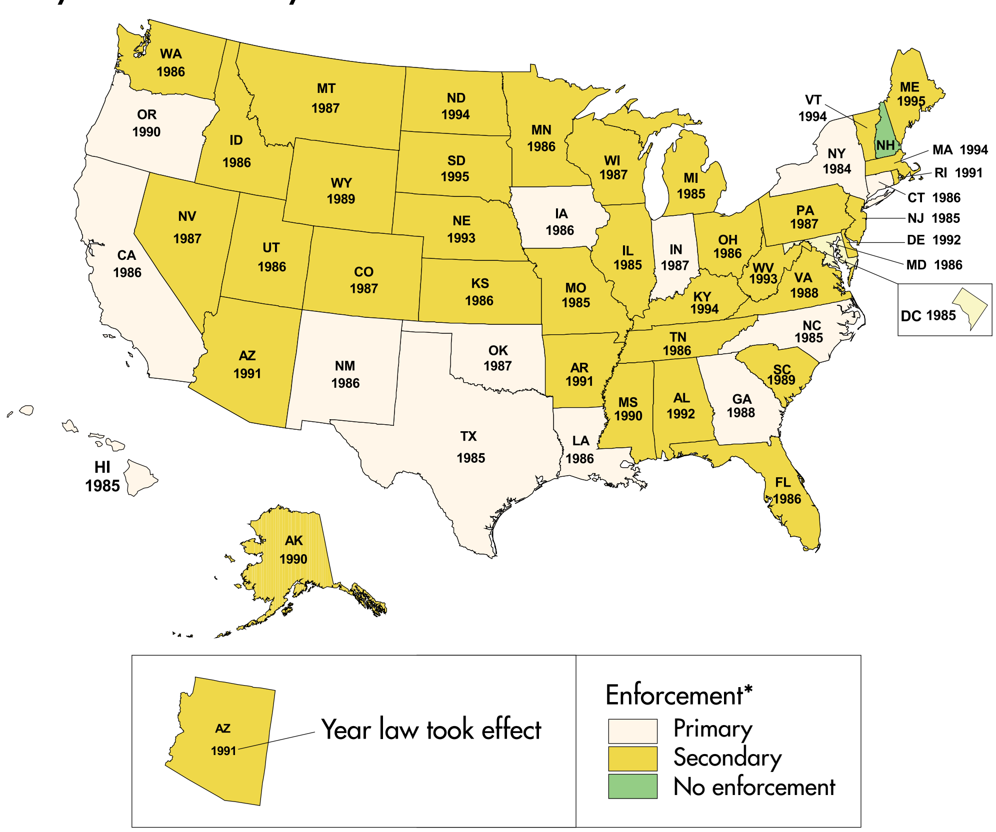
Estimated Number of Lives Saved Each Year by Use of Safety Belts: 1975-98
(Annual totals)



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Figure 3-13

Key Provisions of Safety Belt Use Laws: 1998



* With secondary enforcement, police officers are permitted to write a citation only after a vehicle is stopped for some other traffic violation. With primary enforcement, police officers can stop vehicles and write citations whenever they observe violations of safety belt laws.

Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

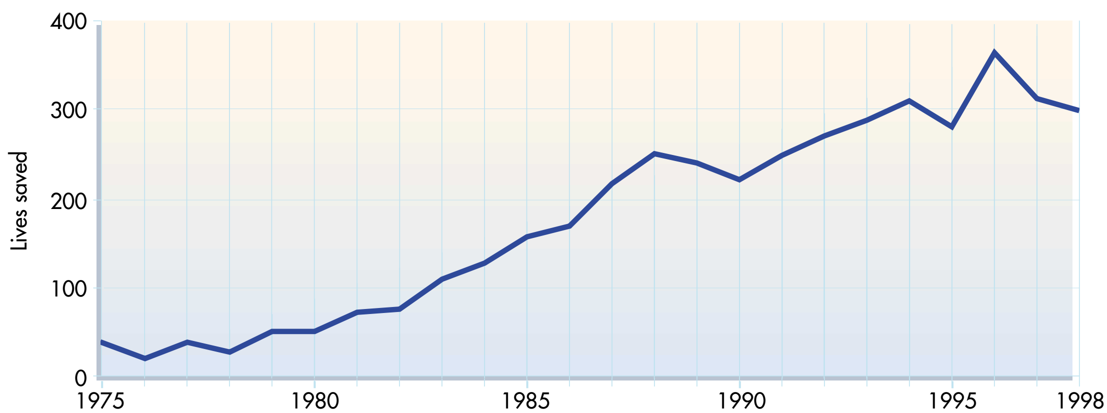
Child Restraints: Standards for child restraint systems in motor vehicles were set in 1971, but major changes were made in 1981. Child restraint systems have been shown to reduce fatal injuries by 69 percent for infants less than 1 year old and by 47 percent for children up to 4 years old [NSC 1999]. All states have had child restraint use laws in effect since 1985, but these laws vary.

The use of child restraint systems has saved an estimated total of 4,193 lives since 1975 (figure 3-14). According to NHTSA, 173 additional lives could have been saved in 1998 if all children less than five years of age were properly restrained in appropriate safety seats [USDOT NHTSA n.d. (a)].

Motorcycle Helmet Standards and State Helmet Use Laws: Motorcyclists have the highest fatality rate of all motorists on the roads. This rank has remained unchanged since 1975, although their fatality rate has decreased from 56.7 to 20 per 100 million VMT. The fatal crash involvement rate for motorcycles also is the highest—22.7 per 100 million VMT in 1998, compared to a rate of 1.9 for passenger cars, 2.2 for light trucks, and 2.5 for large trucks [USDOT NHTSA n.d. (b)].

Figure 3-14

Estimated Number of Lives Saved Each Year by Use of Child Restraints: 1975-98 (Annual totals)



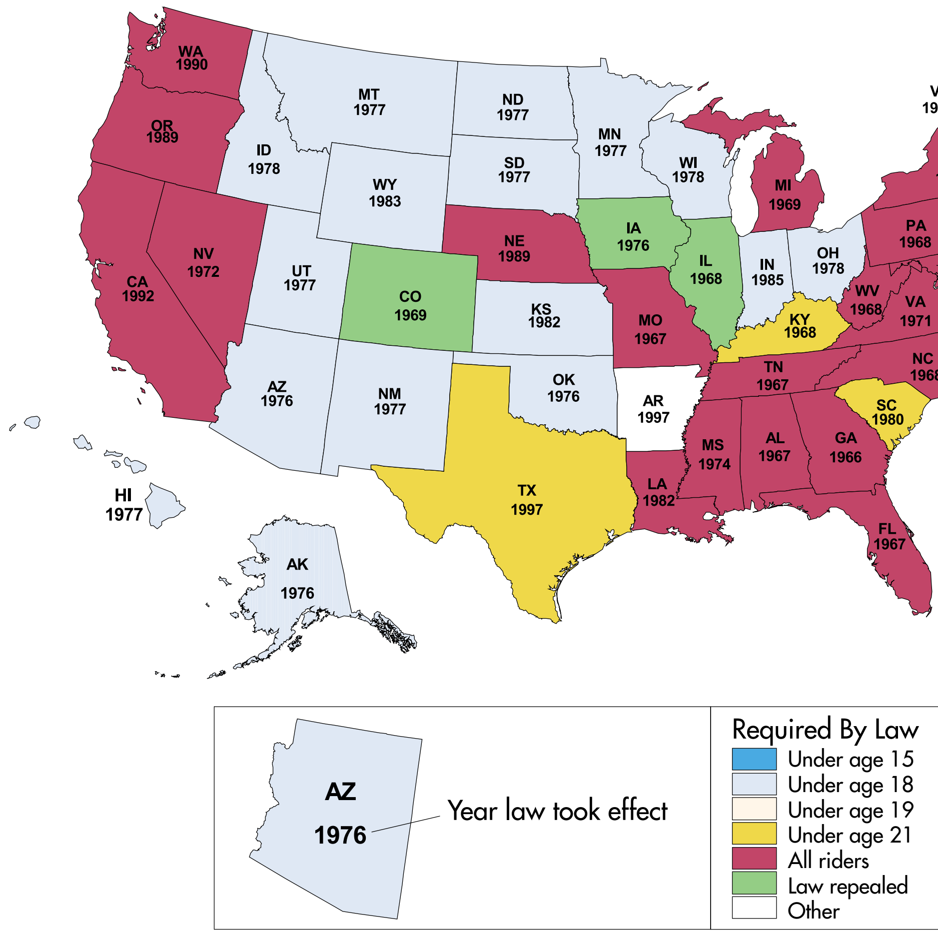
Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

NHTSA performance standards for motorcycle helmets went into effect in 1974. In 1998, 22 states, the District of Columbia, and Puerto Rico required all motorcycle riders to use helmets. In another 24 states, only riders under 18 years of age are required to wear helmets, while 3 states have no laws regarding helmet use (figure 3-15).

A 1998 NHTSA survey estimated the use of helmets at 67 percent nationwide [USDOT NHTSA n.d. (b)]. Previous NHTSA surveys have shown helmet use at nearly 100 percent in states with universal helmet use laws and as low as 34 percent in states with limited or no helmet use laws. The use of helmets saved the lives of an estimated 500 motorcyclists in 1998 (figure 3-16). An estimated 307 additional lives might have been saved that year if all motorcyclists used helmets. The use of motorcycle helmets reduced the risk of fatal injuries to motorcyclists by an estimated 29 percent [USDOT NHTSA n.d. (b)].

Figure 3-15

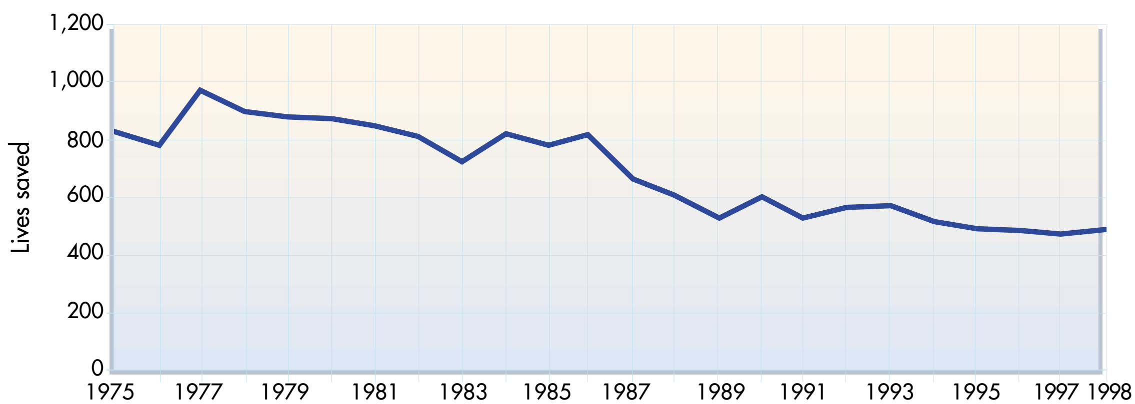
Motorcycle Helmet Use Laws: 1998



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Figure 3-16

Estimated Number of Lives Saved Each Year by Use of Motorcycle Helmets: 1975-98
(Annual totals)



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Demographic Characteristics (age)

Increasing numbers of younger and older drivers—the highest risk segments of the population—will create a new highway safety challenge in the 21st century. In 1998, 40 percent of the drivers who died in crashes were in one of these two age groups—23 percent in the 16-to-24-year age group and 17 percent were in the 65-and-older age group [USDOT NHTSA 1999a]. The traffic crash fatality rate per 100,000 population is the highest in the 16-to-24-year age group, followed by those over age 74 (figure 3-17).

The expanding U.S. population—a 23 percent increase is expected by 2025 [Hollmann et al. 2000]—will lead to an increase in the number of drivers on the road, and changing demographics in the United States will result in a shift of drivers from younger to older age groups. The 17 million licensed drivers 70 years old and older in 1999 [USDOT NHTSA 1999a] could increase to as many as 25 million by 2025 [Slater 2000]. Therefore, we must take steps to address the needs of this growing sector of our population.

Box 3-4

Older Drivers and Technologies

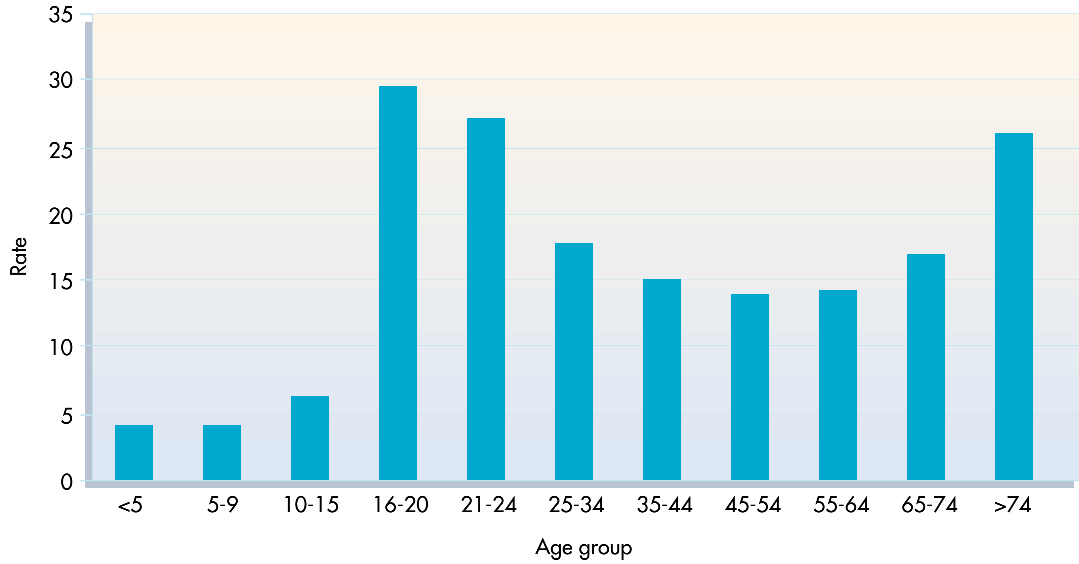
As the "baby boom" generation ages, the safety of older drivers will become an even greater concern. Although older people use automobiles less than younger ones, they are nonetheless highly auto-dependent. Among urban people 75 to 84 years of age, 90 percent of all trips are by automobile, and for urban people 85 years and older, 86 percent of all trips are by automobile. In rural areas, the comparable dependency figures are 94 and 83 percent, respectively. The automobile is the dominant mode of travel among older people, and it likely will remain so.
In the future, we may expect that seniors will tend to *age in place* as they do today. Many will stay in their existing residences in suburban, exurban, or rural neighborhoods rather than relocate to retirement communities. They will, therefore, be highly dependent on the private automobile; and as they get older, driving will likely become more difficult. Many older people are aware of their limitations and reduce their driving in difficult circumstances or voluntarily discontinue it. As a result, their incidence of automobile crashes per licensed driver is less than for other groups (see figure 3-18).

Older people are less able to survive the trauma of crashes (see figure 3-19). When they are victims of automobile crashes, people over 80 are four times more likely to die than 20-year-olds. With many more older adults driving in the future, the fatalities for this population segment will probably climb faster than for the overall population. This scenario presents a formidable challenge for future transportation managers, but opportunities abound to counter this trend by making highways and automobiles safer and providing better options for other transportation services, such as public transportation and paratransit.

Highway engineers have begun updating standards for signs, control devices, and highway and intersection designs to provide increased consideration for the needs of an aging population. In future vehicles, a number of new technologies should become operational that will protect and aid older drivers, particularly vehicle collision and crash avoidance warning systems, speech navigation, and information and warning systems. But designs also must be found to make future vehicles more crashworthy for older, more fragile drivers and passengers.

Figure 3-17

Persons Killed per 100,000 Population in Highway Crashes by Age Group: 1998



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Vehicle Characteristics

NHTSA sets safety standards for all motor vehicles. These standards are designed to improve vehicle safety in the event of a crash (crashworthiness standards) and to improve the vehicle so drivers can better avoid collisions (crash avoidance standards). Over the last three decades, NHTSA has set crashworthiness standards covering a wide range of issues, including:

- side impact protection,
- vehicle rollover stability,
- roof crush resistance,
- air bags,
- safety belts,
- fuel system integrity,
- head restraints,
- upper interior protection,
- advanced windshield glazing,
- school bus safety,
- child safety seats,
- flammability of interior materials,
- heavy truck underride, and
- advanced air bags.

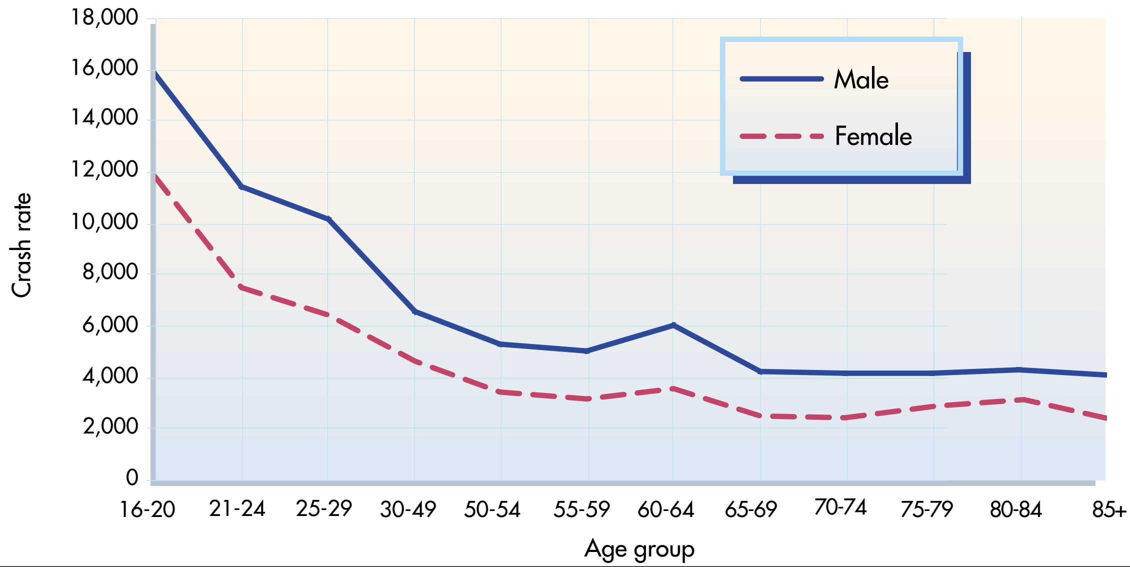
Crash avoidance standards have included:

- antilock brakes,
- center high-mounted stop lamps,
- heavy truck conspicuity,
- electronic brake controls,
- heavy truck splash and spray, and
- school bus visibility issues (i.e., mirrors and signal arms).

This is just a partial list of the changes implemented to protect vehicle occupants and others who use the roadways. NHTSA also conducts crash tests on vehicles under the New Car Assessment Program. This program was initiated in 1979 and provides consumers with crashworthiness ratings for new model vehicles. Together these regulations and programs have helped contribute to the dramatic decline in fatality rates since 1975, preventing thousands of fatalities and injuries every year.

Figure 3-18

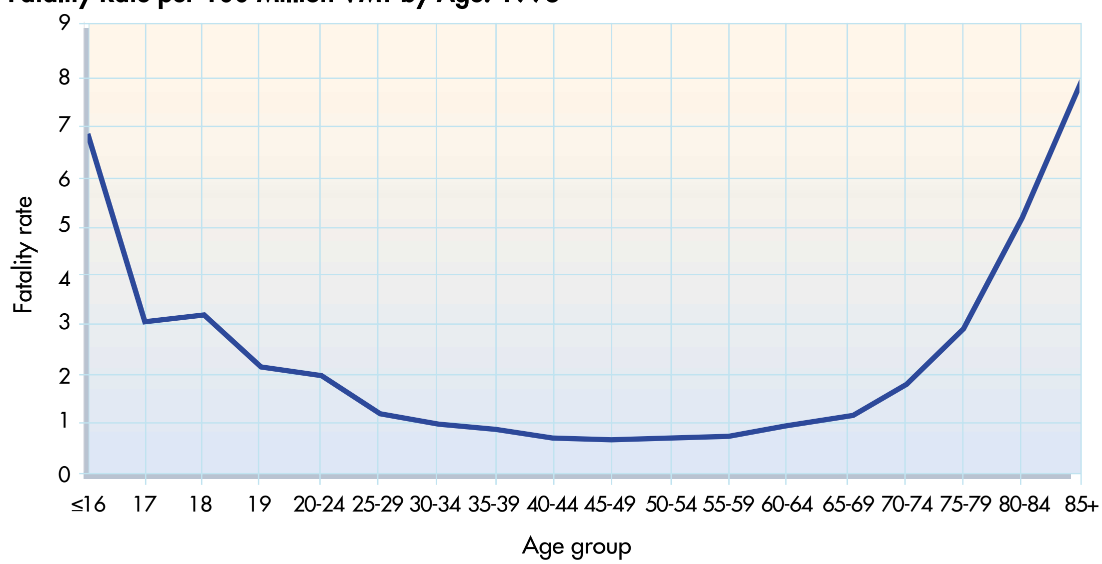
Crash Rate per 100,000 Licensed Drivers by Age and Gender: 1998



Note: Data not included for the District of Columbia.
Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Figure 3-19

Fatality Rate per 100 Million VMT by Age: 1996



Note: Data not included for the District of Columbia.
Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

USDOT, NHTSA

As part of its new car assessment program, the National Highway Traffic Safety Administration uses a 35-mph frontal impact test to measure the crashworthiness of the 1999 Volkswagen Beetle.

Aside from safety belts, perhaps the most well-known vehicle safety feature is air bags. Automobile manufacturers sold air bags as optional equipment for many years before they became required equipment for cars in 1997 and for multipurpose passenger vehicles, trucks, and buses in 1998. NHTSA estimates that air bags saved 3,706 lives from 1975 through 1998, including 1,043 in 1998 (figure 3-20).

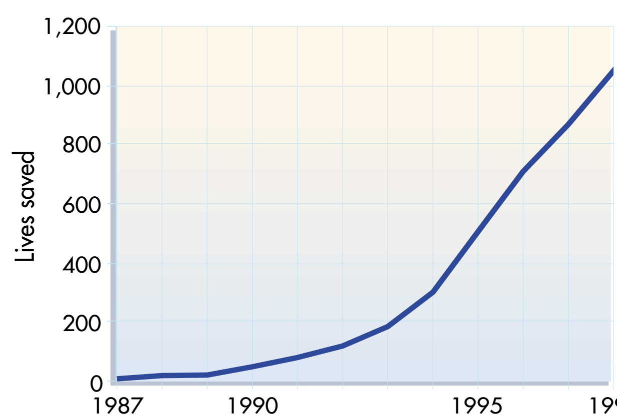
Air bags have been at the center of controversy due to the deaths of vehicle drivers and passengers from air bags that deployed in a small number of low-speed crashes. Through April 1, 1999, 78 children and 60 adults have been killed by air bags in such crashes [Insurance Institute 2000]. Children under 12 have been most vulnerable. In most of these cases, the children were in rear-facing child restraints, improperly placed in front seats, or were unrestrained; most of the adults were unrestrained.

NHTSA has adopted new requirements, to be phased in over the next few years, to minimize the risk of injury from air bags. Vehicle manufacturers are developing smart air bags using microsensor technologies (crash severity sensors, occupant weight and proximity sensors, and safety belt and seat-position sensors) to adjust the air bag deployment rate during a crash to reduce injuries.

Additionally, some popular models of vehicles are now fitted with side air bags to reduce the risk of injury from side impact crashes.

Figure 3-20

Estimated Number of Lives Saved Each Year by Use of Air Bags: 1987-98 (Annual totals)



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Road Characteristics

Safer Roads: Since 1975, FHWA leadership, advocacy, and other programs have provided progressively higher safety standards and guidance for road design, construction, and maintenance practices, which have been adopted by highway authorities nationwide. All federal-aid projects are required to improve or maintain safety. Examples of road infrastructure safety improvements to reduce crash impacts include installing or upgrading breakaway poles, safety barriers, and crash attenuators. Examples of road infrastructure safety improvements to reduce crashes include rumble strips, travel lanes, shoulders, roadside clear zones, and traffic control devices.

Evaluations of the two special programs, the Federal-aid Hazard Elimination Program and Rail-Highway Crossing Program, suggest that these two safety programs contributed to preventing 58,000 deaths and 1.1 million nonfatal injuries between 1974 and 1995 [USDOT FHWA 1996].

New technologies being incorporated into the road infrastructure for safety include improved safety monitoring and driver advisory systems, such as changeable message signs and radio, high visability signs and markings, new and improved materials and designs for crashworthy devices and traffic control devices.

Speed Limits: In 1973, Congress set a National Maximum Speed Limit (NMSL) of 55 miles per hour (mph) as a temporary energy conservation measure. States that failed to enforce the speed limit faced highway-funding sanctions [USDOT FHWA 2000b]. Safety advocates, citing a decrease of 9,000 highway fatalities during the first year, backed the speed limit as a safety measure. It became permanent in 1974.

As the memories of the gas crisis of the 1970s faded, pressure began to build, especially in western states, for the repeal of the 55-mph speed limit. In 1987, the federal government gave states the option of an NMSL of 65 mph on rural Interstate highways and certain rural freeways without risking the loss of federal highway funds. In December 1995, the NMSL was repealed completely, and full authority to set speed limits on public roads was returned to states and local communities.

Since 1995, all states except the District of Columbia and Hawaii have raised the speed limit on some or all of their Interstate highways. Figure 3-21 shows current maximum rural Interstate speed limit by state. NHTSA is collecting travel speed and crash data to determine if there is conclusive evidence of an association between speed limits and crashes.

Box 3-5

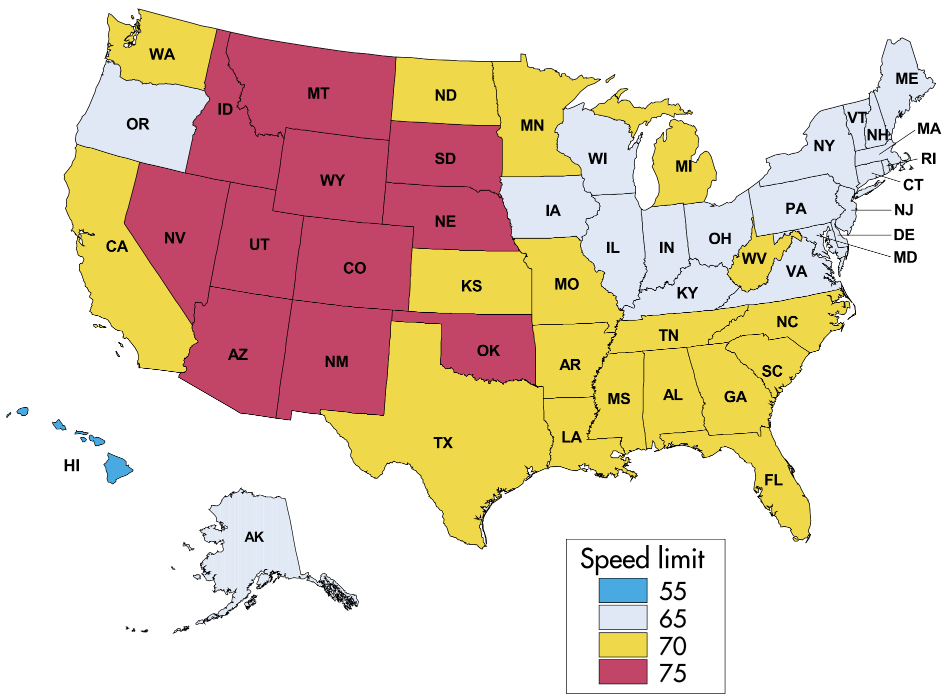
Speed Management and Variable Speed Limit Technology

Speed management involves matching speed with roadway design and area characteristics. Many factors must be taken into consideration, including type and amount of roadside development, road design, accident experience, pedestrian presence, and weather conditions. Speed management practices include setting realistic speed limits, traffic calming techniques, and public education.

One technology-based speed management approach is the variable speed limit (VSL), which sets speed limits appropriate to weather and traffic conditions. VSL has been used successfully in Europe to adjust speed limits to improve safety and traffic flow. VSL is a part of the Intelligent Transportation System (ITS) group of technologies.

Figure 3-21

Maximum Rural Interstate Speed Limits: 2000



Note: Data not included for the District of Columbia.

Source: U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration (NHTSA), *Traffic Safety Facts 1998* (Washington, DC: 1999); and USDOT, NHTSA, personal communication, October 2000.

Safety Data

Better Data and Safety Management Systems: Availability of better data has improved our understanding of the causes of highway crashes and has allowed us to measure the success of safety efforts. Safety management systems and better safety data now are used by many states to identify safety concerns and to determine which initiatives are most beneficial in reducing crashes.

Before 1975, it was difficult to study the causes of motor vehicle crashes because there was no national-level database. In 1975, the Fatal Accident Reporting System (FARS) was established by NHTSA to create a national-level database of the most severe motor vehicle crashes, those involving a fatality. Since then, these data have been updated and analyzed each year, factors contributing to crashes have been studied, and improved measures have been developed. FARS was later renamed the Fatality Analysis Reporting System.

FARS data are supplemented by another database developed by NHTSA in 1988, the National Automotive Sampling System. This database has two components: the General Estimates System (GES) and the Crashworthiness Data System (CDS). The GES contains data from a nationally representative sample of law enforcement-reported crashes of all severities, including those resulting in death, injury, or property damage. The CDS database includes additional detailed information on an annual sample of approximately 5,000 law enforcement-reported traffic crashes across the country, which are studied in great by crash investigators.

The FHWA established the Highway Safety Information System (HSIS), which provides a sample database of highway safety and road inventory data from each state. It is used to study highway safety issues, direct research efforts, and evaluate effects of safety measures.

Together, these systems provide an overall measure of highway traffic safety and are used to identify traffic safety problems, suggest solutions, and provide a basis on which to evaluate the effectiveness of motor vehicle safety standards and highway traffic safety initiatives.

Box 3-6

Safety In Numbers

The *Safety In Numbers* project was developed in response to Secretary Slater's 1999 National Transportation Safety Conference, where stakeholders identified better data collection and reporting across all jurisdictions as one of the top priorities for safety improvement.

Under this initiative, four Safety Data Workshops were organized by the Bureau of Transportation Statistics (BTS) in September and October 1999, with a concluding national conference held in April 2000, in Washington, D.C., to gather input and develop an action plan for improving the quality of safety data. Organized along "modal" lines, these workshops (two surface transportation and one each for aviation and maritime transportation) brought together more than 200 stakeholders representing the diverse interests of the transportation community, such as nonprofit organizations, associations, businesses, government (state, local, and federal), advocacy organizations, and academia.

These workshops laid the foundation for a "Safety Data Action Plan" with BTS as the lead USDOT agency for improving data quality and ensuring intermodal collaboration. Key issues addressed in this plan include improving data quality, timeliness, and relevance; developing methods for examining safety intermodally; developing data standards; increasing data accessibility and sharing; and using technology to automate data collection and dissemination.

Keys to the Future

Over the last 25 years, the highway fatality rate has dropped steadily, reaching an all time low of 1.5 per 100 million VMT in 1999. However, the rate of decrease has slowed in recent years, and we are seeing "diminishing returns" on current safety improvement efforts. If the current fatality rate is not reduced and VMT grows at the current rate of 1.96 percent annually, about 60,000 people will be killed on the highways in 2015.

In order to continue the trend of significant yearly reductions in the VMT fatality rate over the next 25 years, greater application of safety management to our nation's roads will be required. It will be necessary to adapt new safety strategies and vehicle technologies to match changing demographics and ever-increasing highway traffic. Vehicle safety also must be enhanced, and occupants must be encouraged to take advantage of the protection provided by safety belts, child safety seats, and motorcycle helmets.

The USDOT has targeted a 20 percent reduction in highway-related fatalities and injuries by 2008. To achieve this goal, safety strategies and advanced technologies will need to address issues such as:

- high levels of alcohol-impaired driving,
- alcohol-impaired pedestrians,
- failure of nearly one-third of the driving population to wear safety belts,
- growing size of vehicles and safety problems due to incompatibility between large and small vehicles,
- high numbers of pedestrian and bicyclist fatalities,
- highway-rail grade crossing fatalities,
- special needs of the rising numbers of aged drivers,
- issues relating to growing population of young drivers,
- rising incidence of aggressive driving and speed-related crashes,
- run-off-road crashes, and
- intersection crashes.

Most of these issues were highlighted during the first-ever National Transportation Safety conference hosted by the USDOT in March 1999 and subsequently during the 2025 Visioning Session on safety. We must remain visionary and vigilant and aggressively pursue actions that promote these strategies.

New, advanced crash-avoidance and vehicle control systems are on the verge of being introduced into the general market for all vehicle types. In the next few years, extensive deployment of these technologies is likely as they become less expensive. Some of these technologies are presented in box 3-6.

Box 3-7

Advanced Vehicle Safety and Control Systems

Night vision enhancement: This technology, which uses an infrared sensor behind the center of the vehicle's grill, detects people, animals, and moving vehicles on the road well before the vehicle's headlights, even high beams, can illuminate them. The image of the person, animal, or vehicle is projected onto a black-and-white head-up display on the windshield in front of the driver.

Drowsy driver detection systems: These systems track driver alertness through observation of eye movements and lanekeeping variation (which is a key predictor variable for detecting driver drowsiness). Drowsy driving can be caused by a combination of sleep loss, driving when circadian rhythms are low (early morning hours and mid-afternoon), or driving for long periods of time. The vehicle devices alert the driver when such behavior is detected.

Adaptive cruise control: Automotive Adaptive Cruise Control (ACC) is a "smart" device that maintains a driver-selected headway interval between vehicles. ACC monitors the headway interval, provides an audible warning, and slows the vehicle when the interval becomes dangerously narrow. Next generation or "Intelligent" systems, once set, will automatically maintain a safe distance, governed by throttle and brake control.

Rear-end collision avoidance: A rear-end collision occurs when safe distance is not maintained due to a driver's unawareness and a lack of safe distance information. Rear-end collision-avoidance systems will typically sense critical information about an impending collision, process the information into a usable form, and present this information to the driver (or directly to the vehicle) in a way that elicits appropriate collision avoidance action. Rear-end collision-avoidance systems may include Driver Warning, Intelligent Cruise Control, and Automatic Control systems.

Collision notification: This is a "Mayday" system for passenger vehicles that automatically and reliably detects the occurrence of a crash and alerts emergency medical services (EMS), police, and fire agencies. The primary objective of the system is to significantly reduce emergency response times for personal injury crashes by automatically assembling and transmitting a cellular telephone message from the vehicle to local emergency agencies. The message would include the vehicle location and crash severity data.

Intersection collision avoidance: This system consists of traffic-actuated warning signs linked to pavement loops and a traffic signal controller to enhance driver awareness of the traffic situation at intersections, particularly unsignalized intersections where signalizing would be prohibitively expensive.

Vehicle stability enhancement: Two countermeasures have been identified by NHTSA to help reduce the incidence of heavy-vehicle rollovers. The first is a Roll Stability Advisory System, which measures the rollover stability properties of a typical tractor-semitrailer as it is operated on the roadway and provides the driver with a graphical depiction of the vehicle's loading condition relative to its rollover propensity. The second countermeasure is a Rearward Amplification Suppression System that selectively applies brakes to wheels to stabilize the vehicle and thereby reduce the incidence of rear-trailer rollover in double- and triple-trailer combination vehicles during crash-avoidance steering maneuvers.

Source: Hagler Bailly, Inc., *The Market for Emerging Technology Applications in Transportation: Market Analysis and Forecast* (Washington, DC: 1999).

Automation of enforcement efforts—monitoring red-light running or speed-limit violations—can help improve crash avoidance by making drivers more aware and increasing compliance and respect for traffic control devices and traffic laws intended to prevent crashes. Further improvements in data collection systems can provide timely information necessary to maximize the effectiveness of safety measures. Strategies relying on more accurate data about trends can be developed to improve public services, such as emergency services, enforcement, and hazardous materials teams.

By the year 2025, we will have made a quantum leap forward in reducing highway fatalities and injuries by dramatically decreasing the number of crashes that occur on America's roadways. Automated cruise control and collision avoidance systems, including interactive systems to prevent collisions at intersections, will be widely available. Detection systems that alert drowsy drivers or prevent the operation of a vehicle by impaired drivers will be more widely accepted and commonly used. Automated observation technologies will permit more effective enforcement of highway safety laws, particularly speeding and red-light running violations, thereby substantially reduce crashes.

Improved safety data and information systems, as well as a better understanding of highway crash causation, will ensure that infrastructure investments are targeted toward the highest hazard locations using the most effective countermeasures available. To make the driving task safer for an older driving population and other users, improved computer-aided highway design—for example, next-generation high-visibility pavement designs, enhanced pavement markings and signs, and other roadside safety hardware—will ensure that we have in place a highway system that actively works to prevent crashes and minimizes the severity of crashes when they may occur.

Motor Carrier Safety

A quarter century ago, the Interstate Commerce Commission (ICC) regulated the economic aspects of the motor carrier industry. The FHWA had responsibility for safety regulation, performing several thousand on-site reviews annually for carrier compliance with both federal safety and hazardous materials regulations.

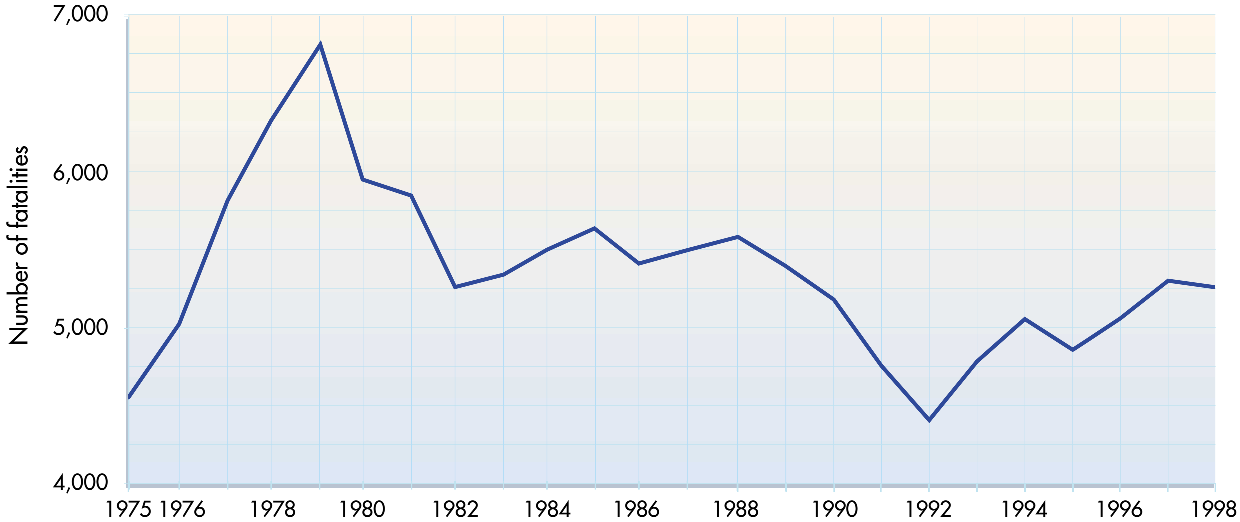
In 1975, about 15,000 carriers had authority to provide interstate transportation for hire [Hill 2000]. Economic deregulation of for-hire interstate truck and bus transportation, signed into law in 1980 and followed by intrastate deregulation, meant that nearly anyone could begin service anywhere. There was a flood of new entrants—mostly small carriers, creating a safety oversight challenge for the FHWA and the states.

Between 1975 and 1998, annual VMT for large trucks more than doubled—from 81 billion miles to 196 billion miles [USDOT FHWA 1975–1998]. Despite this increase in large-truck VMT, both the fatality rate and total crash incident rate per 100 million VMT have decreased for large trucks. The number of fatalities, however, has risen over the same period. In 1999, 5,203 people were killed in crashes involving large trucks compared to 4,500 in 1975. Figure 3-22 shows the fatalities in large truck crashes from 1975 to 1998. On average, 80 percent of those killed in large-truck crashes were nonmotorists or occupants of other vehicles involved in the crash [USDOT FMCSA 2000a].

In the mid-1970s, about 18,000 roadside driver-vehicle safety inspections were conducted each year by a small federal field staff [Hill 2000]. In 1982, Congress enacted the Motor Carrier Safety Assistance Program, a multimillion-dollar grant program under which states perform roadside driver/vehicle inspections and carrier on-site compliance reviews. By 1999, more than 2 million inspections per year were being conducted (figure 3-23) mostly by states. Figure 3-24 shows the percent of vehicles and drivers removed from service ("out of service") as a result of these roadside inspections.

Figure 3-22

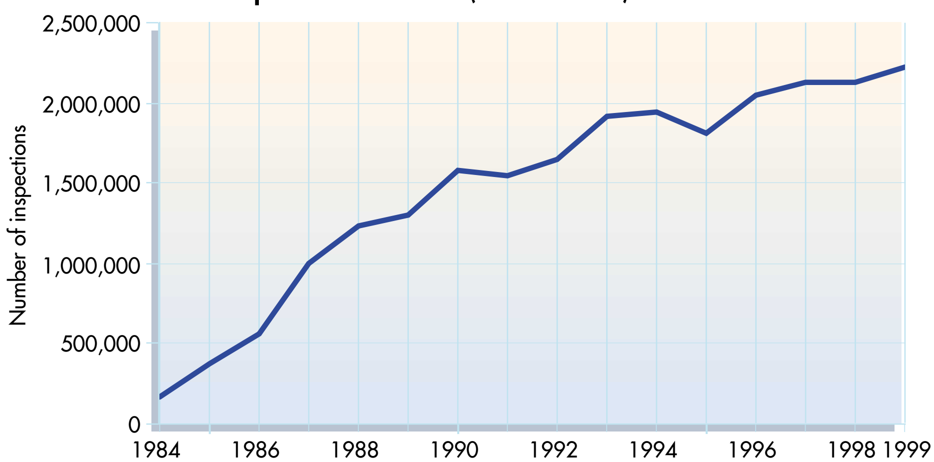
Fatalities in Large Truck Crashes: 1975-98 (Annual totals)



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Figure 3-23

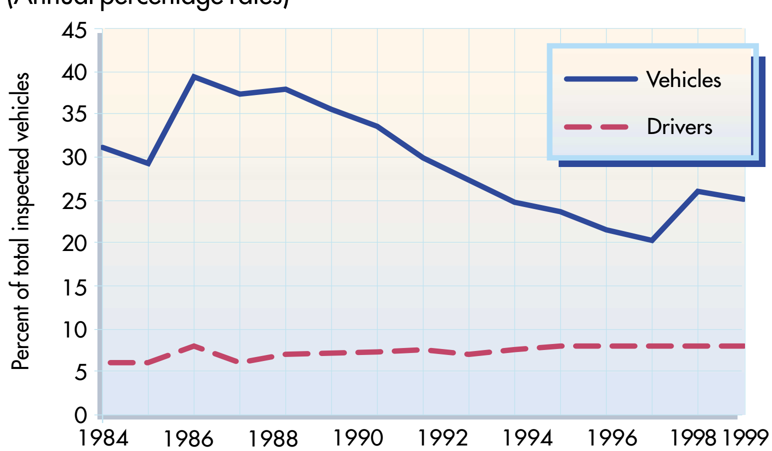
Number of Vehicle Inspections: 1984-99 (Annual totals)



Source: U.S. Department of Transportation, Federal Motor Carrier Safety Administration, Motor Carrier Inspection Database (Washington, DC: Various years).

Figure 3-24

Out-of-Service Inspections*: 1984-99
(Annual percentage rates)



* Roadside inspections that result in the vehicle and/or driver being removed from service for violating Federal Motor Carrier Safety Regulations or Federal Hazardous Materials Regulations.

Source: U.S. Department of Transportation, Federal Motor Carrier Safety Administration, Motor Carrier Inspection Database (Washington, DC: Various years).

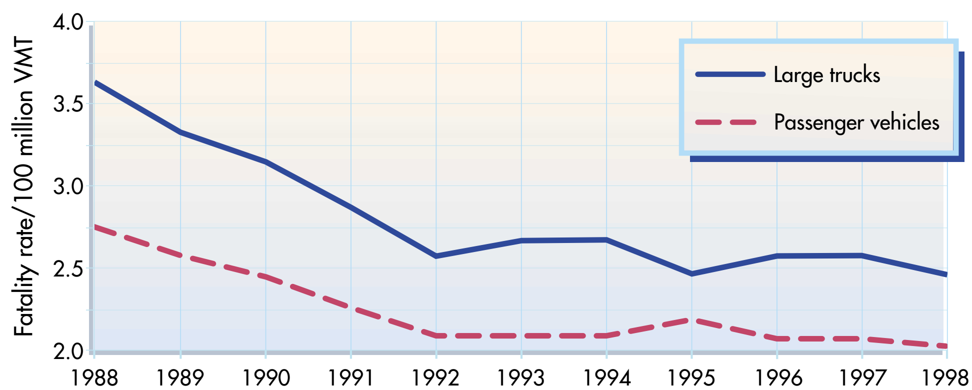
By the mid-1980s, with deregulation, ease of entry, and limited safety oversight, the FHWA requested and received authority from Congress to hire 300 additional inspectors to enforce safety regulations [Hill 2000]. The FHWA also expanded its information systems to gather additional safety information on all interstate motor carriers whose number had expanded to more than 190,000 [USDOT FMCSA 2000b].

Other major safety actions quickly followed. Under a 1987 law, commercial truck and bus drivers are prohibited from having more than one commercial driver's license (CDL), thereby preventing operators from circumventing driving suspensions by spreading citations among licenses from various states. Another change was that drivers were required to pass comprehensive road tests in the vehicles they were to operate. Subsequent changes included mandatory drug and alcohol testing of commercial drivers, which began in 1990; improved medical screening; and a 1994 ban on radar detectors in commercial vehicles.

By the late 1990s, the FHWA was able to use its data system to target high-risk carriers for on-site compliance reviews to bring them into regulatory compliance or, in the worst cases, levy fines or even suspend operations. Most states also have adopted the Federal Motor Carrier Safety and Hazardous Material Safety Regulation standards or have state laws comparable to these federal standards for trucks that operate only within the state and, therefore, are not subject to federal regulations. States also have increased enforcement efforts to improve compliance with these safety standards. As a result of these safety initiatives, NHTSA estimates show that the involvement rate of large trucks in fatal crashes per 100 million large truck VMT decreased from 4.9 in 1975 to 2.5 in 1998. Figure 3-25 shows the decline in fatal crash involvement rate (per 100 million VMT) for large trucks between 1988 and 1998.

Figure 3-25

Fatal Accident Rate for Large Trucks and Passenger Vehicles: 1988-98 (Annual totals)



Source: U.S. Department of Transportation, Federal Motor Carrier Safety Administration, *Large Truck Crash Profile: The 1998 National Picture* (Washington, DC: 2000).

To further improve the enforcement of motor carrier safety programs and reduce fatalities from crashes involving large trucks, the Federal Motor Carrier Safety Administration (FMCSA) was created by the Motor Carrier Safety Improvement Act of 1999. This legislation provided increased resources to target:

- increased roadside inspections,
- compliance reviews and enforcement actions,
- improved safety data,
- additional research into the causes of crashes,
- increased education for highway drivers,
- review of the CDL program, and
- close monitoring of new truck and bus drivers.

Keys to the Future

On January 1, 2000, the FMCSA began its life with the ambitious goal of reducing fatalities in crashes involving trucks and buses by 50 percent over the next 10 years. This target, the centerpiece of the Commercial Motor Vehicle Safety Action Plan, was announced by the Secretary of Transportation in May 1999.

Current trends suggest that over the next 25 years, the number of large trucks and their VMT may continue to grow significantly. The North American Free Trade Agreement (NAFTA) and the expanding international freight trade also may create more truck traffic. If truck travel continues to grow at its current rate, the miles traveled will increase by approximately 55 percent by 2025 to more than 300 million truck-miles per year. Given this growth rate, large truck fatalities would be expected to increase to over 8,300 in 2025 if the current fatality rate of 2.7 fatalities per 100 million miles traveled does not change. However, we can do better. Our stretch goal of reducing motor carrier-related fatalities by 50 percent by 2010 will propel further reductions by 2025. The FMCSA and the trucking industry will be challenged to reduce deaths while the motor carrier industry grows rapidly. The major challenges likely to be faced include:

- collecting accurate information to allow field staff to focus on motor carriers and drivers identified as the highest safety risks and to remove problem carriers and drivers from the road;
- increasing safety awareness among the driving public on how they can better cope with trucks and buses on the highways;
- increasing safety awareness among commercial drivers and safety personnel in the area of fatigue recognition and management;
- developing standards for the many new motor carriers expected to enter the industry; and,
- using technology advances—crash avoidance systems, early hazard detection, countermeasures for driver fatigue, and roadside brake examination on moving vehicles—to increase safety in the truck and bus industries.

Possible long-range solutions include:

- imposing crashworthiness requirements to reduce fatalities in truck/car collisions,
- requiring new carriers to demonstrate knowledge of existing safety regulations,
- setting aggressive and accountable goals for states to reduce fatalities,
- imposing stiffer requirements on CDL applicants for traffic and drug- and alcohol-related violations, and
- establishing a National Commission to study how economic considerations may affect drivers' decisions to drive for longer periods without rest.

The momentum developed to meet the 2010 goals could propel us to even higher levels of safety. While crashes involving large trucks are frequently deemed not to be the fault of the operator of the truck, advanced technological systems installed in trucks together with carefully targeted investments will continue to reduce large truck-related fatalities. By 2025, a target of reducing fatalities far beyond the 50 percent goal by 2010 is entirely feasible.

Transit Safety

In 1975, transit, like the intercity rail system, was beset by serious financial difficulties. As transit ridership steadily declined from the late 1940s through the early 1970s, public agencies were forced to bail-out the financially beleaguered private transit operators. The public agencies kept transit systems operating, but limited funds remained for system upgrades and safety improvements.

In the past quarter century, fare increases, public funding, and, recently, increased ridership to more than 9 billion have improved the financial stability of transit agencies. New equipment and tracks, better safety training, and tougher federal and state oversight have produced transit systems that are safer and more efficient.

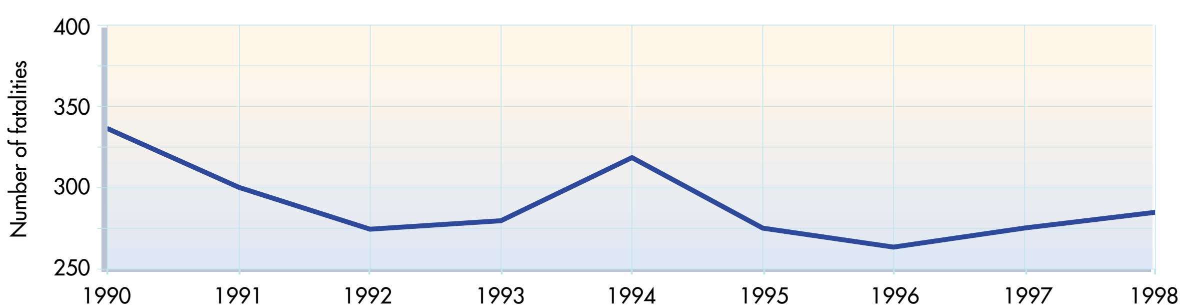
Twenty-five years ago, the major focus of most transit agencies was to generate enough funds to continue operating. Many transit systems considered operating funds to be top priority, while maintenance for aging tracks and vehicles was a lesser concern. These systems could not afford new equipment.

Beginning in 1975, transit systems received some relief from the pressures of generating operating expenses with the first federal operating assistance and an increase in federal funds for capital assistance. When the Federal Mass Transit Account was established in 1983, funded by a penny-per-gallon gas tax, transit systems began receiving even more federal capital funds, freeing more of their own money for operating expenses. Many state and local governments also recognized the financial crisis facing transit agencies and came to their aid; some provided direct aid, and others provided dedicated local tax revenues. As these funds were combined with revenues from the farebox, transit agencies gradually began to invest in system improvements and new equipment. Greater attention also was focused on preventing operator errors through better training and stricter enforcement of drug and alcohol standards.

Between 250 and 300 people die annually in transit incidents (figure 3-26), and about 55,000 people are injured, according to the Federal Transit Administration (FTA). Figure 3-27 shows the declining trend in transit incidents between 1990 and 1998 (fatality and injury data are unavailable before 1990). There are more deaths and injuries on bus systems than on other transit modes, more incidents per million vehicle-miles on light rail than on other modes, and more deaths per 100 million unlinked passenger trips on commuter rail systems.

Figure 3-26

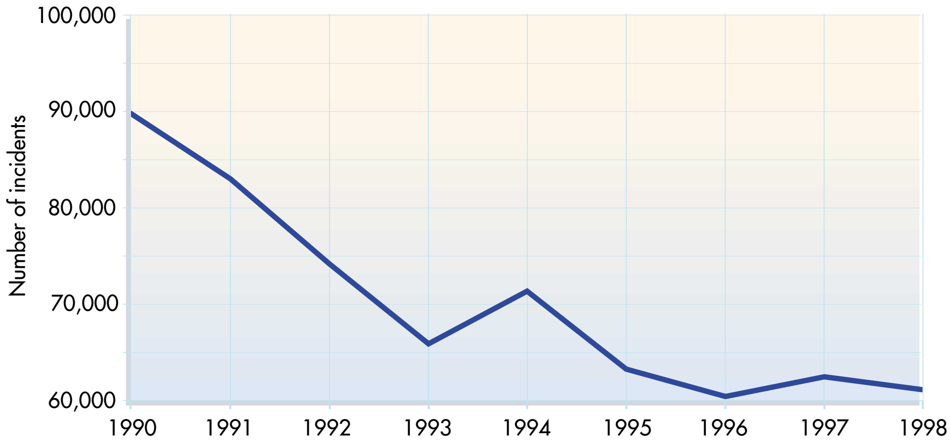
Fatalities in All Transit Incidents: 1990-98
(Annual totals)



Source: U.S. Department of Transportation, Federal Transit Administration, Safety Management Information System (Washington, DC: 1998).

Figure 3-27

Transit Incidents: 1990-98
(Annual totals)



Source: U.S. Department of Transportation, Federal Transit Administration, Safety Management Information System (Washington, DC: 1998).

In 1995, Congress mandated the FTA to create the State Safety Oversight program, requiring states to manage the safety of rail transit systems and to develop system safety program standards. This requirement applies to 34 transit agencies in 22 states. Commuter rail safety is covered by Federal Railroad Administration (FRA) safety standards.

Keys to the Future

If current trends continue, transit systems will be carrying more riders early in the new century—particularly the aging U.S. population, which may create more transit demand for ridership.

Increased investment in new and better equipment by transit agencies is one solution for providing the safety needed for increasing ridership. Recently, transit agencies have joined in testing railcars and railcar windows. New technologies (e.g., rear collision avoidance, lane change and merge collision avoidance, road departure warning, and pedestrian/passenger sensing) also promise to increase the margin of safety.

Transit agencies also can provide improved safety education and training for the workforce. In 1999, the Transportation Safety Institute provided more than 53,000 hours of training for transit workers.

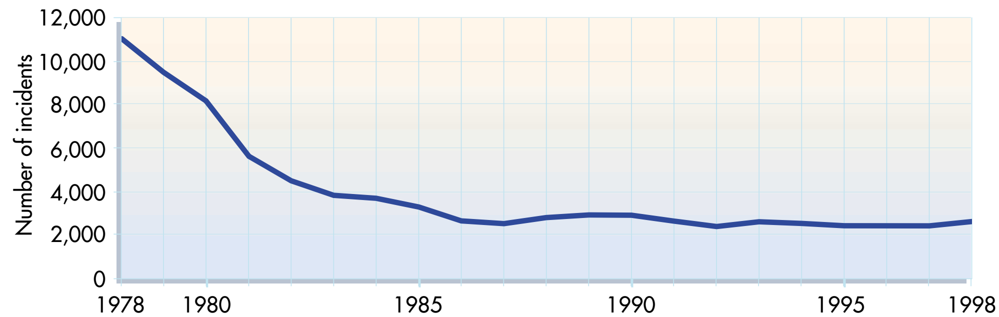
Railroad Safety

In 1975, much of the U.S. railroad industry was hobbled by major financial problems. Railroads, struggling to survive, lacked the funds to maintain existing infrastructure or buy new equipment. Deteriorating track and aging railcars and other equipment posed significant safety threats.

Following economic deregulation in 1980, the railroads gradually regained financial strength and the resources to reach higher safety levels. Today, with increasing rail traffic, safety has improved and the number of railroad-related crashes and fatalities have decreased (figures 3-28 and 3-29). But, we can do more—the FRA has set a 5-year goal to reduce the rate of fatalities fatalities in rail-related incidents by 25 percent [USDOT FRA 1999].

Figure 3-28

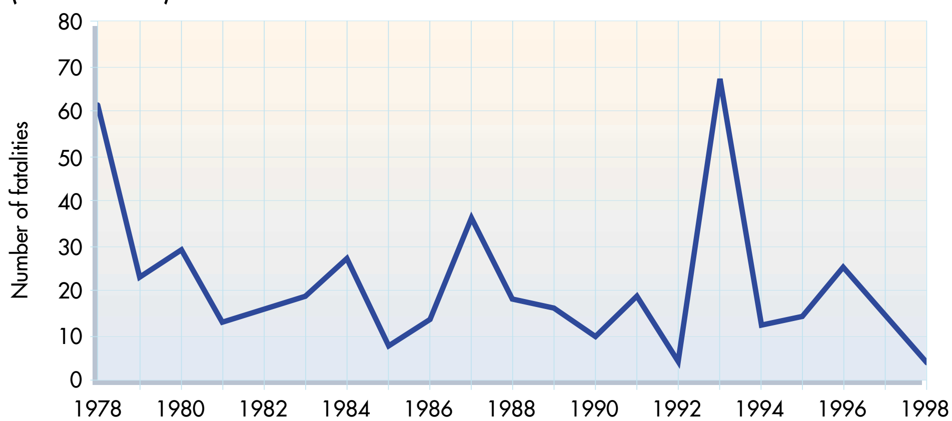
Total Train Incidents: 1978-98
(Annual totals)



Source: U.S. Department of Transportation, Federal Railroad Administration, *Accident/Incident Overview* (Washington, DC: Various years).

Figure 3-29

Fatalities in Train Incidents: 1978-98
(Annual totals)



Source: U.S. Department of Transportation, Federal Railroad Administration, *Accident/Incident Overview* (Washington, DC: Various years).

Significant challenges in the railroad industry have confronted the USDOT from the time of its creation in 1966. The FRA was granted broad safety rulemaking authority under the Federal Railroad Safety Act of 1970 [Public Law 91-458] and set the first federal track safety standards in 1971 [36 *Federal Register* 20336] and, in 1973, set freight car safety standards [38 *Federal Register* 32230]. The new regulations did not immediately improve the railroads' safety performance. In 1978, total train crashes, excluding highway-rail grade crossing and trespass incidents, reached 10,991 with 61 fatalities, including 24 deaths resulting from the release of hazardous materials from 232 railcars involved in train crashes [USDOT FRA 2000].

Part of the problem in the mid-1970s was that economic regulation curtailed the railroad industry's ability to generate sufficient revenues to maintain its infrastructure. The Staggers Rail Act of 1980—legislation that liberalized the regulatory environment for railroads—initiated the industry's return to financial recovery. Safety improved with increased investment in railroad infrastructure, including technologically advanced physical plant and equipment. At the same time, the industry was faced with new, higher safety standards set by the FRA, ranging from crashworthiness standards for tank cars to alcohol and drug testing regulations for operators and other workers.

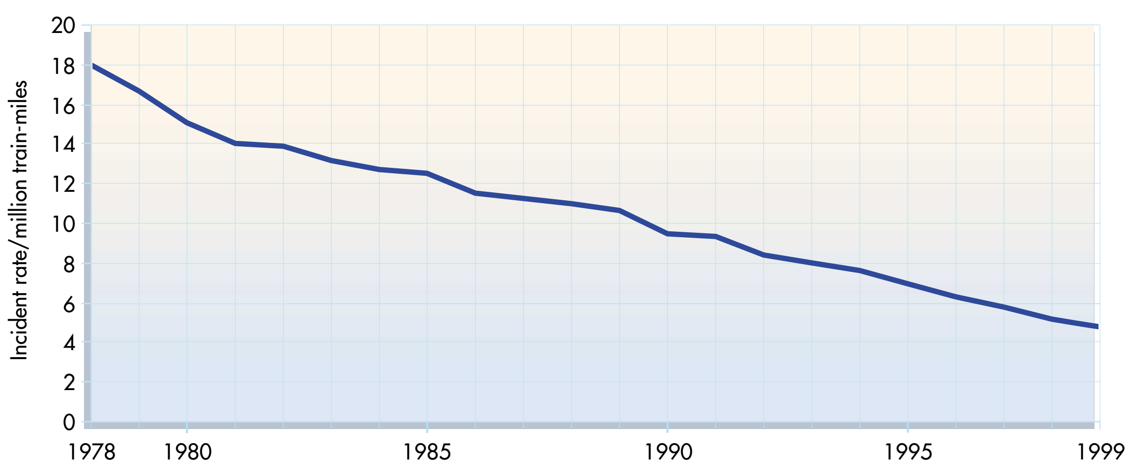
As a result of these measures, rail-related injuries dropped by 75 percent between 1978 and 1993 [USDOT FRA 2000]. During the same period, incidents declined by more than 75 percent while the incident rate per million train-miles dropped by more than 65 percent. The highway-rail grade crossing incident rate was reduced by more than 75 percent, from 18 per million train-miles to 4.8 per million train-miles (figure 3-30). Since 1980, only three people have died as the result of hazardous materials release in train crashes [USDOT FRA 2000].

These substantial safety improvements took place while freight railroad traffic increased to a record 1.1 trillion ton-miles by 1993. The fatality rate per million train-miles stayed nearly constant from 1978 to 1993, but with FRA's new safety inspection program and continuing investment, the rate then decreased by 38 percent from 1993 to 1999 (figure 3-31). From 1993 to 1999, despite increases in highway and train traffic, incidents at highway-rail crossings decreased by 29 percent, and crossing deaths decreased by 36 percent. Figure 3-32 shows the location of grade crossing fatalities in 1998. Overall railroad fatalities fell by 27 percent, and total railroad injuries fell by 39 percent [USDOT FRA 2000]. In 1999, only 39 hazardous materials releases were due to train crashes—an 83 percent drop since 1978 [USDOT FRA Annual issues].

FRA promotes strategic partnerships with rail labor, management, suppliers, state rail safety agencies, and other rail stakeholders. through the advent of this partnership concept, begun in 1993, a new safety culture has emerged within the railroad industry to implement safer operating practices and procedures. This new safety culture, along with technological advances, permits new and innovative practices to be adapted and thereby improve the overall safety of the industry as well as the quality of life of the employee.

Figure 3-30

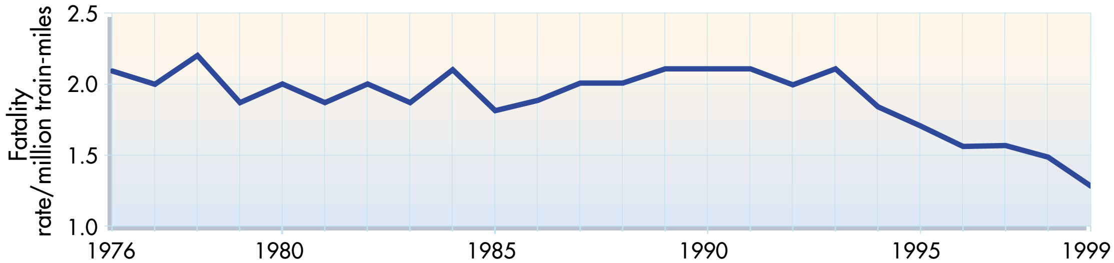
Highway-Rail Grade Crossing Incident Rate: 1978-99



Source: U.S. Department of Transportation, Federal Railroad Administration, Annual Safety Statistics, (Washington, DC: Various years).

Figure 3-31

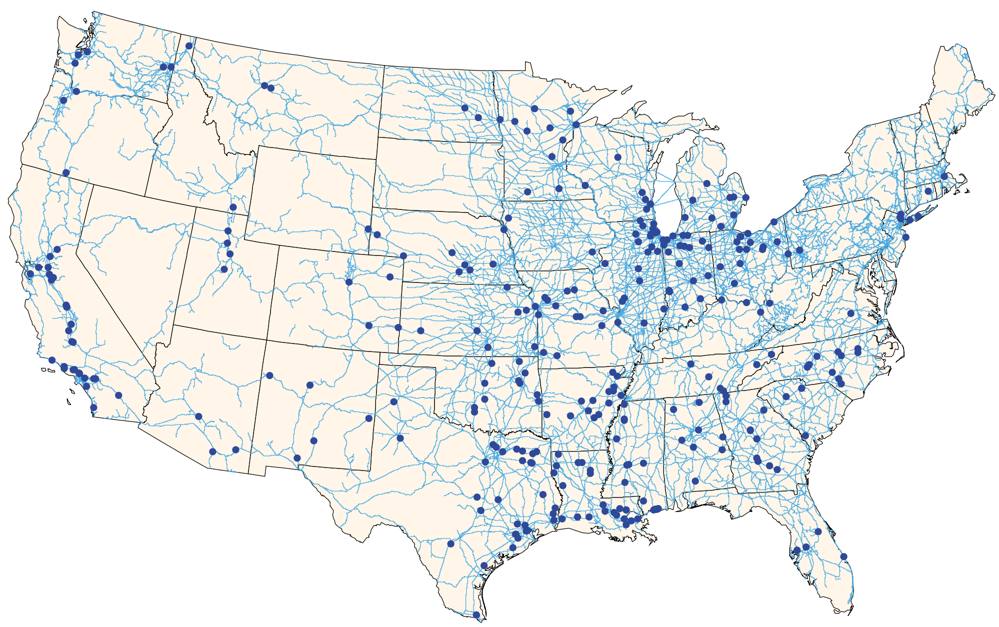
Rail-Related Fatality Rate, Including Highway-Rail Grade Crossings: 1976-99



Source: U.S. Department of Transportation, Federal Railroad Administration, Annual Safety Statistics (Washington, DC: Various years).

Figure 3-32

Grade-Crossing Fatality Locations: 1998



Source: U.S. Department of Transportation (USDOT), Federal Railroad Administration, Offices of Policy and Safety, special tabulations (Washington, DC: 2000); and USDOT, Bureau of Transportation Statistics, National Transportation Atlas Database 2000.

Box 3-8

Highway-Rail Grade Crossings

Combined public and private action has been successful in eliminating thousands of crossings and reducing fatalities and grade crossing crashes. Figure 3-33 shows the decline in highway-rail grade crossing fatalities. Between 1974 and 1993, 49,000 public grade crossings were eliminated. In 1994, the USDOT developed the Rail-Highway Grade Crossing Safety Action Plan, whose implementation eliminated another 9,000 public grade crossings. The 1996 Federal Railroad Administration (FRA) requirement for all locomotives to have warning lights also helped produce significant reductions in the rate of grade crossing incidents. To add another safety precaution, Congress required FRA to issue rules preempting state and local laws banning the sounding of locomotive horns at public grade crossings. FRA also has expanded and strengthened its partnerships with groups such as Operation Lifesaver. As a result of these measures, deaths at highway-rail grade crossings have declined by more than half since the late 1970s [USDOT FRA 2000].

(continued on next page)

Box 3-8 continued

Highway-Rail Grade Crossings

Still, many rail-related fatalities—402 in 1999—result from collisions between trains and motor vehicles at railroad crossings. About 159,000 public grade crossings remain, with about 20 percent having automatic gates and another 20 percent having flashing lights [USDOT OIG 1999]. Figure 3-34 shows the highway-rail grade crossings by active and passive controls. Almost one-third of the more than 3,000 grade crossing collisions in 1999 (and 42 percent of the fatalities) occurred in five states: California, Illinois, Indiana, Louisiana, and Texas [USDOT FRA 2000]. FRA focuses a broad-based approach in these states including education and enforcement under Operation Lifesaver and through public announcements. Under proposed FRA rules, communities wishing to prohibit the sounding of locomotive horns at public grade crossings may be required to implement other grade crossing improvements, such as four-quadrant gates, photo enforcement, and roadway medians.

Today, trespassing has become the leading cause of railroad fatalities [USDOT FRA Annual issues]. Each year, approximately 500 people are killed as a result of trespassing on railroad rights-of-way. Railroads face the challenge of identifying sites vulnerable to trespassing, improving awareness, and installing fencing.

In 1997, after the merger of Union Pacific and Southern Pacific, concerns about merger-related safety problems—blending different corporate cultures and reconciling different operating rules and practices—arose. To address these concerns, the FRA, the Surface Transportation Board, and the two railroads worked jointly to develop Safety Integration Plans (SIPs)—blueprints to ensure critical safety needs were addressed. CSX and Norfolk Southern (NS) implemented SIPs as part of their acquisition of Conrail. Despite well-publicized service problems, reported crashes and injuries decreased in the realigned CSX and NS territories.

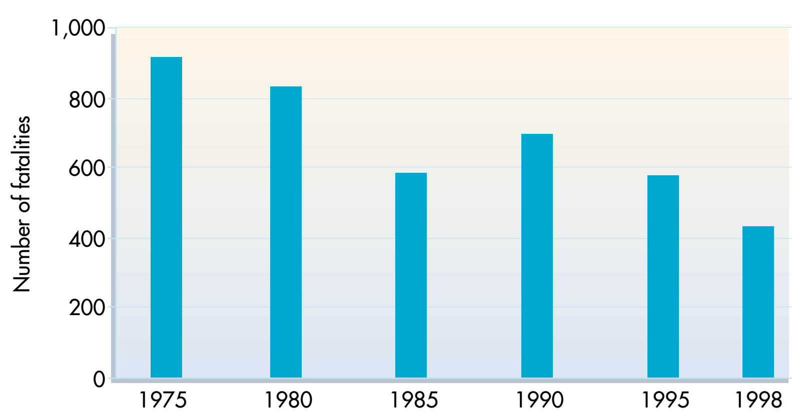
"Our challenge is about saving lives. It is about ensuring that more people arrive home safely each and every day — people who work on railroads, travel on railroads, and live near railroads. Our results speak for themselves. The years 1993-1999 were the safest seven years in rail history."

Jolene Molitoris
Administrator,
Federal Railroad Administration

In the past seven years, the safety focus has moved from site-specific inspections and enforcement to a cooperative industry-government partnership to identify and solve systemwide safety problems. This paradigm shift is the same as the work between NHTSA and its partners that focuses on prevention and not just response. As a result, safety regulations rules have been issued on bridge protection, maintenance of way, trackside workers, passenger train emergency preparedness, passenger equipment, two-way end-of-train devices, and track safety standards. Partnerships also were formed to address highway-rail crossings and to develop recommendations on other safety issues. In the first 6 years of this new cooperative safety approach, the fatality rate per million train-miles declined by 27 percent [USDOT FRA 2000]. Inspections, violation reports, and fines also were reduced. Today, approximately 400 FRA safety inspectors, joined by 150 state inspectors, monitor compliance with FRA safety regulations.

Figure 3-33

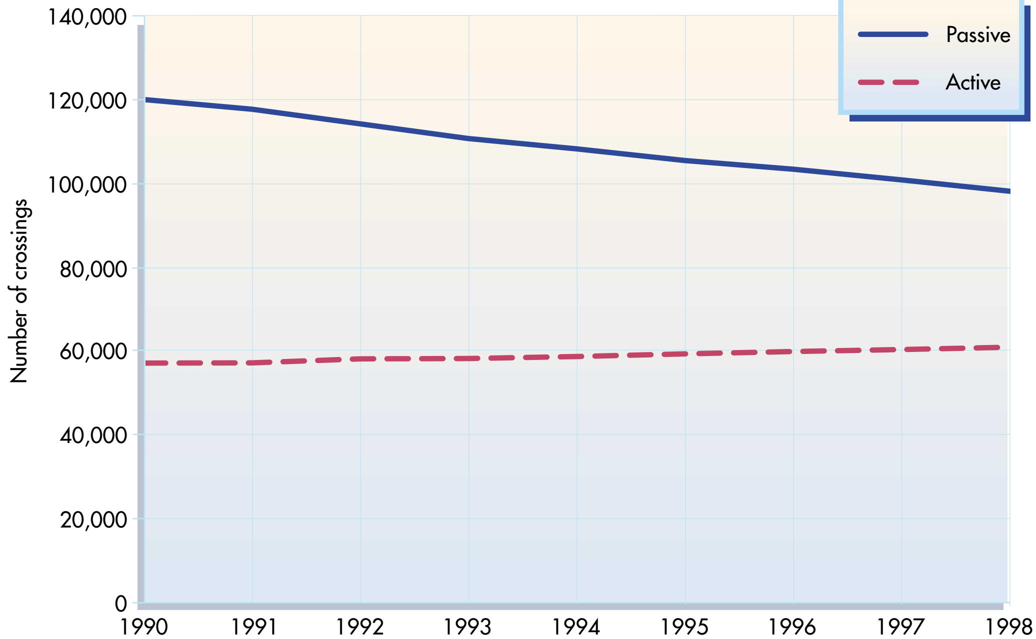
Highway-Rail Grade-Crossing Fatalities: 1975-98



Source: U.S. Department of Transportation, Federal Railroad Administration, *Railroad Safety Statistics Annual Report* (Washington, DC: 1998).

Figure 3-34

Number of Highway-Rail Grade Crossings by Active and Passive Controls: 1990-98
(Annual totals)



Source: U.S. Department of Transportation, Federal Railroad Administration, *Railroad Safety Statistics Annual Report* (Washington, DC: Annual issues).

Keys to the Future

Based on FRA's current safety programs and strategies, its goal is to achieve an entire year with *zero* employee-on-duty fatalities before the year 2025. FRA has also set the goal of reducing highway-rail grade-crossing fatalities 75 percent by the year 2025 to fewer than 100 per year. Working with its rail industry partners, FRA hopes to cut the train accident rate by nearly 50 percent by 2025 [USDOT FRA 1999]. Further progress in rail safety requires continued partnership between FRA and the rail industry to actively address the following key issues, as called for during the 1999 National Transportation Safety Conference:

- researching, testing, evaluating, and implementing alternative grade crossing technologies to prevent highway grade crossing accidents;
- researching human factors, including fatigue, which hamper operator alertness, resulting in crashes;
- promoting safety in high-speed train operations, including those reaching 90 to 150 mph on existing railroad rights of way; future trains reaching 200 mph using advanced steel-wheel-on-rail systems on largely new rights of way; and trains reaching 300 mph with magnetic levitation (maglev), where magnetic forces lift, propel, and guide a vehicle over a specially designed guideway;
- safe sharing of mainline freight track with light rail, commuter rail, and intercity passenger operations; and
- deploying positive train control systems (box 3-8).

To improve safety, the FRA and the railroad industry are examining ways to develop Intelligent Railroad Systems that would incorporate new digital communications technologies into positive train control, electronically controlled braking systems, grade crossings, and defect detection in tracks.

The FRA recognizes that there are many contributing aspects to human factor-caused train incidents, such as fatigue and train operator experience. The FRA is exploring more sophisticated ways of developing and analyzing data associated with these incidents. The FRA also is working with the railroads to strengthen job training and compliance with safety regulations.

Box 3-9

Technology for Rail Safety

Intelligent Railroad Systems use digital communications technologies for train control, braking systems, grade crossings, and defect detection to make the railroad system safer. New electronic sensors, computers, and transmission systems will help railroads detect hazardous equipment and track conditions and prevent collisions and derailments.

- Positive Train Control (PTC) systems will use digital data link communications networks, positioning systems, and on-train and control center computers to maintain assured separation between trains.
- Electronically controlled pneumatic brakes will substantially shorten braking distance by using an electronic signal to simultaneously apply all brakes on a train.
- Intelligent grade crossings with sensors will send information about trains to highway traffic control centers and to motorists through roadside traffic information signs. Sensors will send information to both trains and railroad control centers if a stalled vehicle blocks a grade crossing.
- Electronic sensors, on or alongside tracks and on locomotives and freight cars, will identify track and equipment problems and transmit the information to train and maintenance crews, and to control centers, in order to stop or slow a train, if necessary, to initiate repairs.
- New high-speed trainsets will have complex, computerized safety systems that are integrated with the safety system for the entire railroad.

Aviation Safety

A quarter century of focus on aviation safety has made air travel an extremely safe mode of transportation. The rate at which major U.S. aviation crashes (hull losses with fatalities) occur has decreased by more than two-thirds in the past two decades [USDOT FAA 2000b].

"Already, there is less than one fatal crash for every one million commercial flights. But we know we can do better still. Any accident, any death in the air is still one too many."

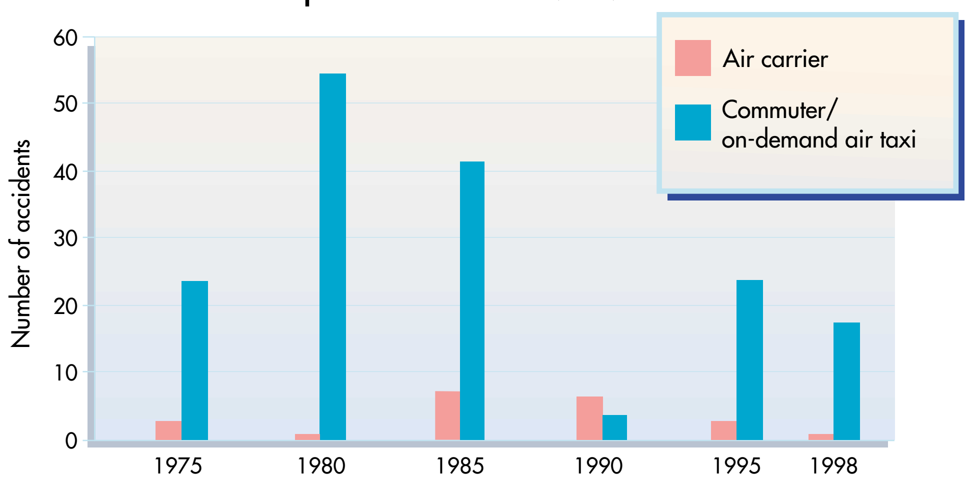
President William J. Clinton
in announcement on airline safety
Jan. 14, 2000

Stricter enforcement, higher standards, evolving technology, and information sharing have combined for continuous long-term safety improvements in air travel for both commercial and general aviation (figures 3-35 through 3-37). Figure 3-38 shows the decline in fatal U.S. air carrier accidents per 100,000 departures since 1978. For example, today, commercial aircraft are equipped to "know" when they are not configured properly and to employ corrective actions. They "know" when they are too close to terrain or too close to each other. In the past 25 years, there have been major breakthroughs in:

- air traffic control system technologies,
- understanding human factors that cause crashes,
- development of simulators used for training pilots,
- airframe and engine reliability,
- onboard automation,
- cabin safety and survivability, and
- crash investigation data.

Figure 3-35

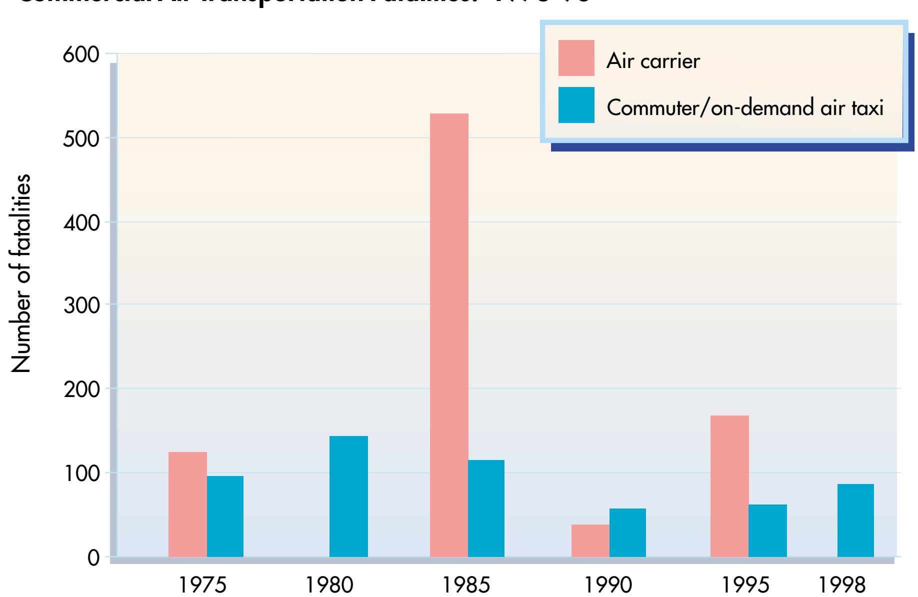
Fatal Commercial Air Transportation Accidents: 1975-98



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1999* (Washington, DC: 1999), Tables 3-9 through 3-13, pages 221-225.

Figure 3-36

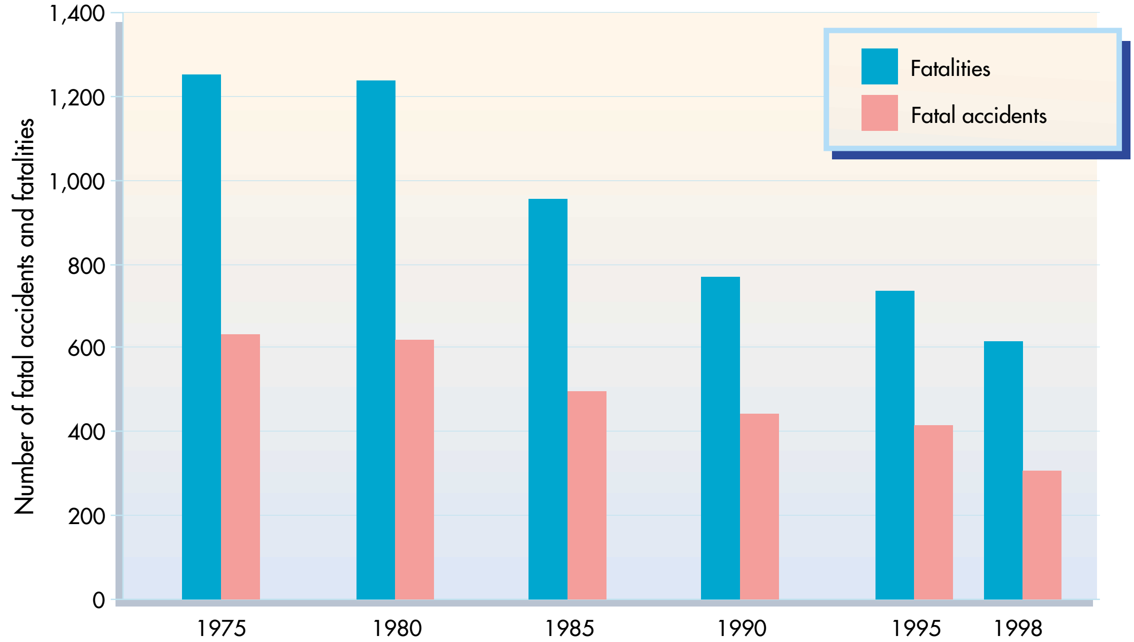
Commercial Air Transportation Fatalities: 1975-98



Note: There was one fatality involving air carriers in 1998.
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1999* (Washington, DC: 1999), Tables 3-9 through 3-13, pages 221-225.

Figure 3-37

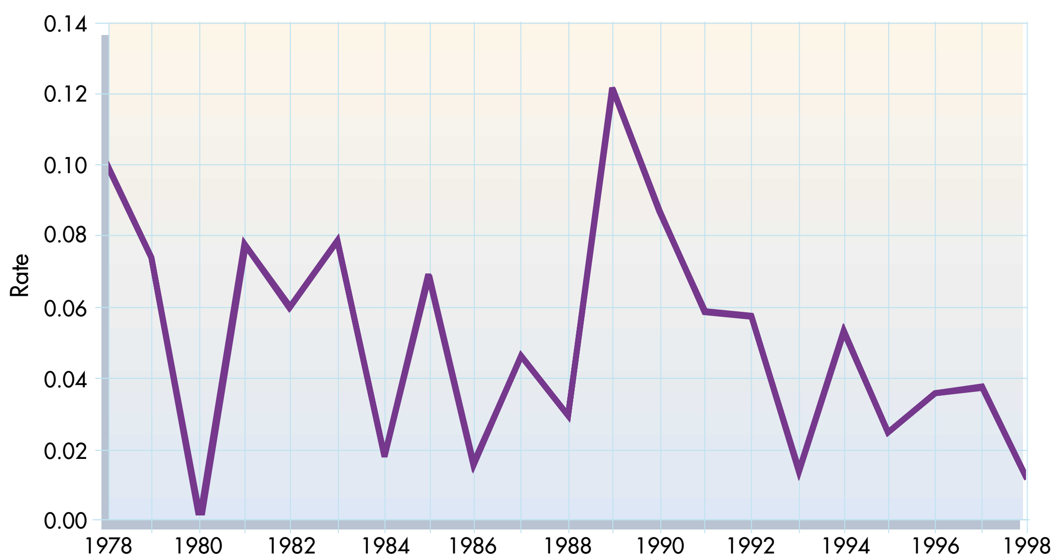
Fatal Accidents and Fatalities in General Aviation: 1975-98



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1999* (Washington, DC: 1999), Table 3-14, p. 226.

Figure 3-38

Fatal U.S. Air Carrier Accidents Per 100,000 Departures: 1978-98



Source: U.S. Department of Transportation, Federal Aviation Administration, personal communication, 2000.

In the early 1970s, the aviation industry did not have a good safety record, prompting criticism of Federal Aviation Administration (FAA) policies. In January 1975, Claude S. Brinegar, the Secretary of Transportation (1973–1975), appointed a special 10-person *Task Force on the FAA Safety Mission* to examine FAA's organizational structure, management, and performance on safety issues. In April 1975, during Secretary William T. Coleman's administration, the task force made recommendations to the FAA that enabled the FAA to improve its organizational efficiency and expedite rulemaking procedures [USDOT FAA OPA 2000]. These improvements allowed the FAA to address some of the most challenging aspects of aviation safety—issues that would remain at the forefront of FAA programs during the next 25 years. Some of the issues addressed by FAA since 1975 are described in the following paragraphs.

Altitude Safety: The FAA examined landing approach procedures following the December 1974 crash of a Boeing 727 into a mountain near Berryville, Virginia, while on approach into Dulles International Airport. Soon after the crash, the FAA implemented higher standards by specifying pilot responsibilities for maintaining safe altitude and specifying the role of air traffic controllers in maintaining pilots' awareness of altitude restrictions.

The agency also expedited work on a technological solution by requiring installation of a Ground Proximity Warning System (GPWS) on large airliners. The system provided both visual and audible warning signals if an aircraft descended too close to the ground. All major airlines were in compliance with the GPWS rule by the end of 1976. In March 1992, the rule was extended to turbine-powered aircraft with 10 or more passenger seats flown by air taxi and commercial operators. More recently, the FAA and industry have taken steps to equip airliners with more advanced terrain awareness warning systems.

Rapid Decompression Standards: In July 1975, the FAA raised standards requiring wide-body jets to withstand the effects of rapid decompression. Concern about aircraft airworthiness was prompted by the March 1974 crash in France of a Turkish Airlines McDonnell Douglas DC-10 wide-body airliner, killing all 346 people on board in the worst air disaster up to that time. In this incident, a cargo door of the jet opened in flight, producing explosive decompression that disabled vital flight-control cables. This series of events led to a broader use of FAA airworthiness directives to ensure in-flight safety of aircraft systems.

Separation Standards: Also in 1975, the FAA increased the standard of distance separation for small aircraft landing behind larger aircraft that are capable of generating wake turbulence. Depending on the size of the lead aircraft, the new procedures required a separation of either four or six miles for the trailing plane. In the 1990s, the FAA modified these standards to give added protection from wake turbulence to small aircraft traveling behind the Boeing 757.

Structural Safety: As the service lives of commercial aircraft are extended, greater focus has been placed on the safety of aging aircraft. This problem was highlighted by a 1988 incident in which structural fatigue caused the opening, in mid-flight, of an 18-foot gap in the fuselage of an Aloha Airlines plane. One cabin attendant was ejected from the aircraft by the force of decompression. The FAA responded with a new approach to aging aircraft—replacement of mandatory inspections with preventive modifications for high-service airliners and the replacement of certain parts after a specified number of flight hours or takeoff-and-landing cycles.

Fire Safety: In March 1977, the full destructive potential of post-crash fire—and the need for higher standards and new technology—was revealed when a fiery runway collision involving a Dutch and a U.S. airliner produced history's worst airline incident at Tenerife, Canary Islands. That incident claimed the lives of 583 passengers and crew. The FAA's

Special Aviation Fire and Explosion Reduction (SAFER) Advisory Committee made a series of recommendations for research and rulemaking.

In 1984, the FAA published two SAFER-based rules on fire-resistant seat cushions and escape-path marking. During the next several years, the agency issued important fire protection rules that included stricter flammability standards for interior materials and improved protection for cargo compartments.

Fire concerns continued into the 1990s. The 1996 crash of a ValuJet DC-9 in the Florida Everglades was traced to a fire in the cargo compartment. The subsequent investigation resulted in new rules banning oxygen generators from the cargo holds of passenger planes, new focus on labeling and handling hazardous materials, and new rules for fire detection and suppression systems in cargo compartments by March 2001 (see the Hazardous Materials Safety section found later in this chapter).

The investigation following the crash of a SwissAir MD-11, in 1998, focused on wiring and insulation and the tests used to determine flammability. Aircraft insulation blankets covered with metalized Mylar were ordered replaced within four years in five types of transport aircraft, and the standard used to determine material flammability was tightened.

Wires and Fuel Tanks: The July 1996 crash of Trans World Airlines (TWA) Flight 800 into the Atlantic Ocean killed 230 passengers and crew. The investigation of that crash heightened attention to the dangers of corroded wires that could ignite fuel tank vapors. Inspections by the FAA and the National Transportation Safety Board (NTSB) determined that the wires near fuel tanks in Boeing 747s and other planes required maintenance. The follow-up included new certification standards and mandatory maintenance instructions on fuel systems for newly designed aircraft, a design review of the fuel tank system of larger existing transports, and a requirement for manufacturers to design specific programs for fuel tank maintenance and protection.

Commuter Airline Safety: As economic regulation of airlines was phased out by legislation enacted in 1978, the FAA adjusted its oversight program. The rules governing air taxis and commuter airlines (Federal Aviation Regulations, Part 135)—the fastest growing segment of the air transportation business—were revised in December 1978 to include mandates for better pilot qualifications and training, more stringent aircraft maintenance programs, and more sophisticated safety equipment. In 1980, the FAA added additional experience requirements for commuter airline crews.

These revisions were designed to bring the safety level of the commuter airlines closer to those of major airlines. In December 1995, the Commuter Safety Initiative set a single level of safety for all travelers by applying the stricter standards of major airlines (Federal Aviation Regulations, Part 121) to commuter airlines that had scheduled passenger operations and/or used aircraft seating 10 to 30 passengers or propelled by turbojets. The rules contained provisions on standards for airplane performance and for flight crew training and qualifications. In addition, the regulations also extended to commuter airline pilots the age-60 rule on mandatory retirement, which had formerly applied to airline pilots flying larger aircraft.

Aviation Safety Reporting: In 1975, the FAA established the Aviation Safety Reporting System (ASRS), designed to collect information on potentially unsafe conditions from airspace users. To encourage reporting of safety problems, the program generally granted immunity from disciplinary action to pilots or controllers filing timely reports. Although immunity programs had been instituted before, the ASRS was the first that did not limit immunity to reports of near midair collisions.

The program was enhanced by an agreement between the FAA and the National Aeronautics and Space Administration (NASA) under which NASA would operate a third-party reporting system, guaranteeing anonymity to individuals providing the data. To help collect safety-related information, the FAA opened a confidential Aviation Safety Hotline in July 1985 for reports of specific regulatory violations.

Collision Avoidance Equipment: The use of airborne collision avoidance equipment was a major technology development of the past quarter century. By 1975, the FAA had already been studying this technology for several years; and by 1981, the agency had pursued a design, which was designated the Traffic Alert Collision Avoidance System (TCAS). In 1989, the FAA directed airlines and commuter operators to install TCAS.

Keys to the Future

Although today's air-incident rate is low, an even lower rate is necessary for the future to improve safety in a rapidly growing aviation industry. Based on projected 15-year growth rates in the industry, current worldwide incident rates will produce an aircraft loss somewhere in the world every eight days [Boeing 2000a, 2000b]. In the United States, the present incident rate would produce an aircraft loss about every three months by 2015. The FAA's 2007 goal is an 80 percent reduction in the air carrier fatal incident rate [Flynn 2000] from the 1994 through 1996 levels.

"The ultimate aim of our efforts is to assure a safe and secure system that enhances the unprecedented levels of mobility we have achieved and which fuels our economic growth while improving the quality of the environment."

Ashish Sen
Director, Bureau of
Transportation Statistics

To achieve this ambitious reduction, major breakthroughs and innovations—new ways of acquiring and sharing knowledge about safety, new ways of setting safety standards, and a new way of working with the aviation community—will be needed. This will require creative strategies that go beyond the government's traditional regulatory role, as well as timely implementation. To further improve aviation's safety record, public and private researchers must work cooperatively to achieve new and innovative breakthroughs from technology, advances in automation, and new human factors knowledge.

The FAA's future safety strategies will focus on a collaborative process that involves working with the aviation community to prevent crashes by finding potential causes. An important element will be new data systems to provide necessary information. These new systems depend on the day-to-day exchange and analysis of operational data by government, industry, and academia. The FAA is working with the aviation community to identify and address potential causes of crashes using data from flight recorders, maintenance reports, and other sources.

"Both Safer Skies and GAIN mark what I think is a historically important shift in direction for aviation safety. Both rely on partnership—on the FAA and the aviation industry working together. Both take a preventive approach. And, both rely on information technology."

Jane F. Garvey
Administrator
Federal Aviation Administration
Third GAIN World Conference
Nov. 4, 1998

Based on detailed analysis of recurrent crash causes, the FAA works with the aviation community to prevent crashes through targeted, systematic interventions. *Safer Skies*, the Administrator Garvey's Safety Agenda [USDOT FAA 2000c], highlights three broad initiatives that will change over time. Commercial Aviation Safety addresses accident causes such as controlled flight into terrain (CFIT), uncontained engine failures, approach and landing, loss of control, and runway incursion. General Aviation Safety addresses causes such as CFIT, weather, loss of control, survivability, aeronautical decisionmaking, and runway incursion. Cabin Safety, the third initiative, addresses passenger interference, passenger seat belt use, carry-on baggage, and child restraints.

The FAA also is working with the worldwide aviation community to develop a privately owned and operated Global Aviation Information Network (GAIN) to collect, analyze, and disseminate aviation safety information. GAIN will dig deeper into the worldwide unreported occurrences of aviation incidents to gather information for their prevention.

To measure success, the agency has specific targets for improvement by specified dates [USDOT FAA 2000a].

1. *Fatal Air Carrier Accident Rate*: By 2007, reduce the U.S. commercial air carrier fatal accident rate per 100,000 hours flown by 80 percent of the 3-year average from 1994 to 1996. This performance goal was the chief safety recommendation of the 1997 White House Commission on Aviation Safety and Security.

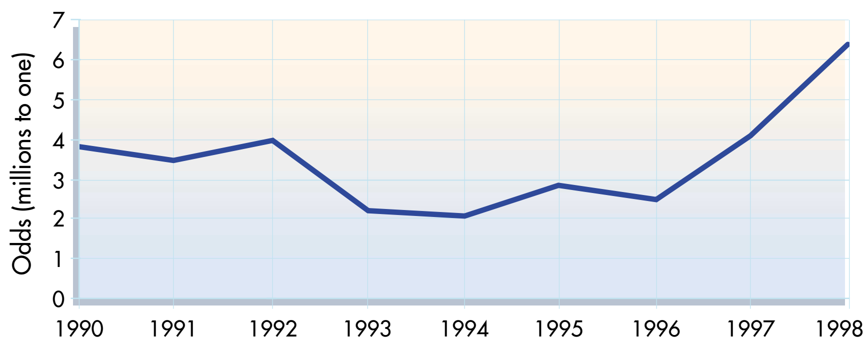
2. *General Aviation Fatal Accidents*: Reduce general aviation fatal accidents to produce a 20 percent improvement over the projected 2007 estimate of 437. This goal was agreed upon by a coalition representing the general aviation community and the FAA.

3. *Occupant Risk*: Increase the probability that passengers and crew will survive an air carrier flight (figure 3-39).

Looking into the future, NASA and the FAA are working together to achieve the long-term goal of reducing the aircraft accident rate by a factor of 5 by 2010, and by a factor of 10 by 2025.

Figure 3-39

Probability that Passengers Will Survive an Air Carrier Flight



Source: U.S. Department of Transportation, Federal Aviation Administration, Working paper on Aviation Safety, draft, March 2000.

Box 3-10

Flight Data Recorders

The first permanent requirement for flight data recorders aboard specific commercial aircraft became effective in 1958. A requirement for Cockpit Voice Recorders followed in 1967. Since then, the requirements have continually expanded—to business-type jets in February 1975, to some existing and newly manufactured large commuter aircraft in 1988, and to new jet and turboprop commuter aircraft in 1989. Voice recorders were mandated in 1988 for all multiengine, turbine-powered commuter and air taxi aircraft able to seat six or more persons with a two-pilot crew. In 1989, the FAA ordered the installation of more sophisticated digital flight data recorders on about

(continued on next page)

Box 3-10 *continued*

2,000 older, large commercial jets. Requirements for voice recorders and flight data recorders also were extended to general aviation aircraft with multiple turbine engines. In recent years, the National Transportation Safety Board (NTSB) and the Federal Aviation Administration (FAA) have been seeking to use advanced recording technology to better identify the causes of aviation crashes and predict trends to prevent future crashes.

Flight Data Recorders

The flight data recorder onboard aircraft records many different operating conditions of the flight that can aid in an investigation in case of a crash. The items monitored can include anything from altitude, airspeed, and heading to flap position, autopilot mode, or even smoke alarms. When used in conjunction with other information gained in the investigation, the flight data recorder and the cockpit voice recorder are playing an ever-increasing role in determining the causes of aircraft crashes.

In 1995, in response to an NTSB recommendation, the FAA called on the aviation industry to begin voluntarily retrofitting Boeing 737 aircraft with upgraded digital flight data recorders (DFDRs). In 1997, the FAA ordered the installation of such DFDRs by August 2001.

The number of specific areas of flight information—data parameters—will be set at 88 for newly manufactured aircraft and will be increased from 11 to 17 or 18 for older aircraft. These parameters deal primarily with information such as the position of flight controls and pilot input.

In response to an NTSB recommendation based on the finding that a rudder malfunction resulted in the deaths of 132 passengers and crew aboard USAir (now USAirways) Flight 427 in 1994, the FAA has proposed additional flight data recorder parameters for the rudder systems of Boeing 737s. Newer Boeing 737s would have upgraded rudder parameters installed by August 4, 2000, while older 737s would have to be in compliance by August 2001.

In response to NTSB recommendations, the FAA also is proposing to increase the 30-minute recording now required on cockpit voice recorders to two hours and to require a 10-minute backup power supply by January 1, 2005. Additionally, the agency is proposing that aircraft built after January 1, 2003, have combination voice and data recording systems. One unit would be close to the cockpit; the other would be in the back of the aircraft.

Maritime Safety

New safety regulations, technological change, education and training programs, and enhanced law enforcement have made our waters much safer than they were 25 years ago. Most fatalities, injuries, and incidents on the water involve recreational boating (which has become an increasingly popular pastime), but fatalities have declined 50 percent since 1975 [USDOT USCG 1999]. Fatalities from commercial vessel operations have decreased by 87 percent from 1975 levels, even though traffic has increased [USDOT USCG 2000c]. Maritime workers still have a fatality rate that is four to five times greater than the average for all other U.S. occupations [USDOT BTS, MARAD, and USCG 1999]. Fishermen are more likely than other maritime workers to die on the job, even though commercial fishing fatalities are down 20 percent since passage of the Commercial Fishing Industry Vessel Safety Act of 1988 [USDOT USCG 1999].

From 1995 to 1999, 60 people died on commercial passenger vessels from all causes (excluding natural causes and diving accidents), and the number of passenger injuries averaged 183 over that same time period [USDOT USCG 2000e]. The NTSB in 1989, and again in 1993, identified serious shortcomings in passenger ship safety and issued recommendations to improve standards for fire protection, crew qualifications, emergency drills, and crew language requirements.

Safety on our waters has improved over the last 25 years as a result of efforts by the U.S. Coast Guard (USCG), in collaboration with industry, the public, and the states. Concerted efforts are being made to improve safety even further. The strides made in the last 25 years and the future direction of safety programs are discussed in detail below for each aspect of the maritime system.

Recreational Boating: Recreational boating fatalities peaked at 1,466 in 1975. In response to the high number of fatalities that year, the USCG implemented an aggressive enforcement campaign to crack down on boaters operating under the influence of alcohol, along with efforts to increase the use of life jackets. As a result of these efforts, recreational boating fatalities declined to 734 by 1999 (figure 3-40). Figure 3-41 shows recreational boating accidents by state in 1975 and 1998.

Of the 815 reported recreational boating fatalities in 1998, 217 were alcohol-related [USDOT USCG 1999], and alcohol was involved in 15 percent of all fatal boating accidents (Figure 3-43). Operating a watercraft while intoxicated became a federal offense in 1998, but the USCG is seeking to tighten enforcement even further by lowering the blood-alcohol content level from 0.10 percent to 0.08 percent in all states (20 states already have a 0.08 percent blood-alcohol concentration limit). This is the same standard used today for motor vehicle drivers [USDOT USCG 2000b].

While jet skis and other personal watercraft are involved in as many accidents as open motorboats, more than five times as many people die in open motorboat accidents [USDOT USCG 1999]. Use of life jackets by jet ski users and the reluctance of many boaters to wear life jackets may be the difference. Although jet skiers are less likely to drown than motorboat passengers, they are much more likely to die from blunt force trauma—the primary cause of death in personal watercraft mishaps [USDOT BTS, MARAD, and USCG 1999].

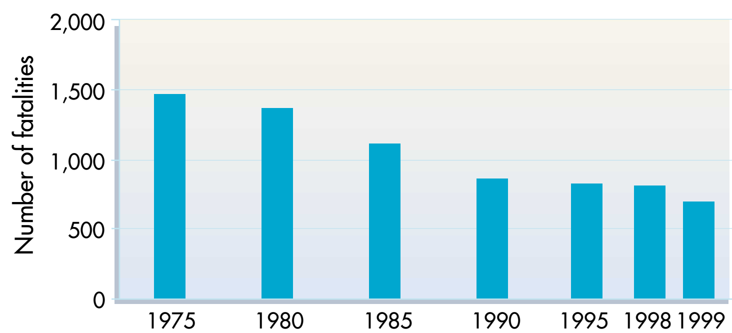
Box 3-11

Growth of Recreational Boats

Today, more people than ever are spending their recreational time on the water, and the number of state-registered recreational boats grows annually (figure 3-42). Adding to the mix of boats and recreational vessels are thousands of personal watercraft, more commonly known as jet skis. According to the National Marine Manufacturers Association, an estimated 106,000 personal watercraft were sold in 1999, up from 29,000 in 1987.

Figure 3-40

Fatalities Involving Recreational Boating: 1975-99



Source: U.S. Department of Transportation, U.S. Coast Guard, Office of Investigation and Analysis, Compliance Analysis Division (Washington, DC: Various years).

Box 3-12

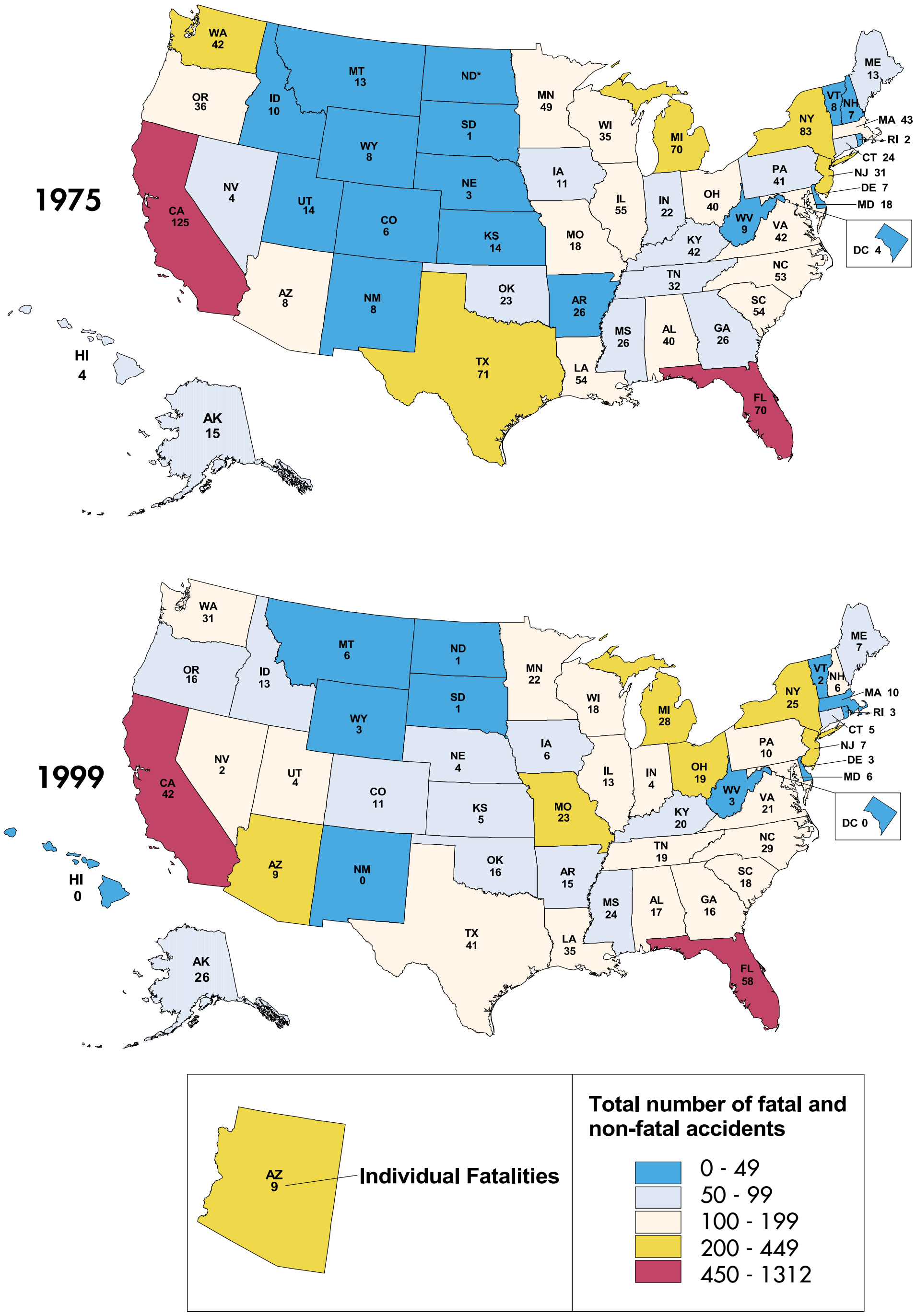
Life Jackets

The vast majority of boating fatalities result from factors that can be controlled or eliminated by individual boaters. Simply wearing a life jacket can vastly improve the chances of surviving a boating accident. About 7 out of 10 boating fatalities are caused by drowning. About 90 percent of these victims were not wearing life jackets.

Source: U.S. Department of Transportation, U.S. Coast Guard, "Campaign Targets Boating Fatalities for Elimination," (news release), available at http://www.safeboatingcampaign.com/2000announce.htm, as of June 19, 2000.

Figure 3-41

Recreational Boating Accidents: 1975 and 1998

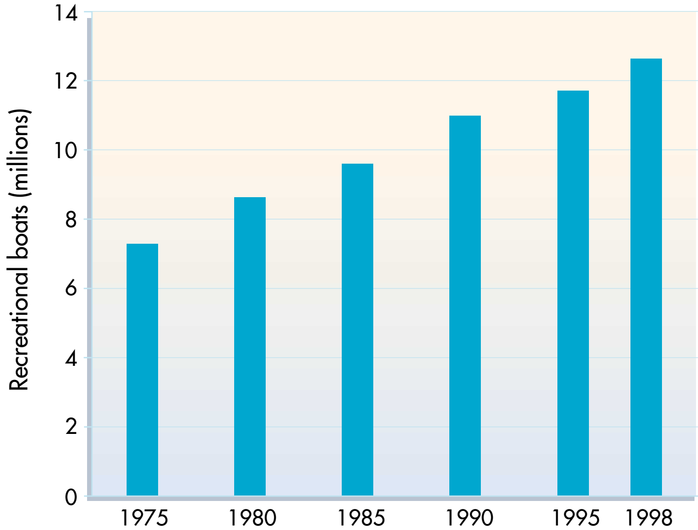


Note: Data on individual fatalities in North Dakota are not available for 1975.

Source: U.S. Department of Transportation, U.S. Coast Guard, *Boating Statistics* (Washington, DC: Annual issues).

Figure 3-42

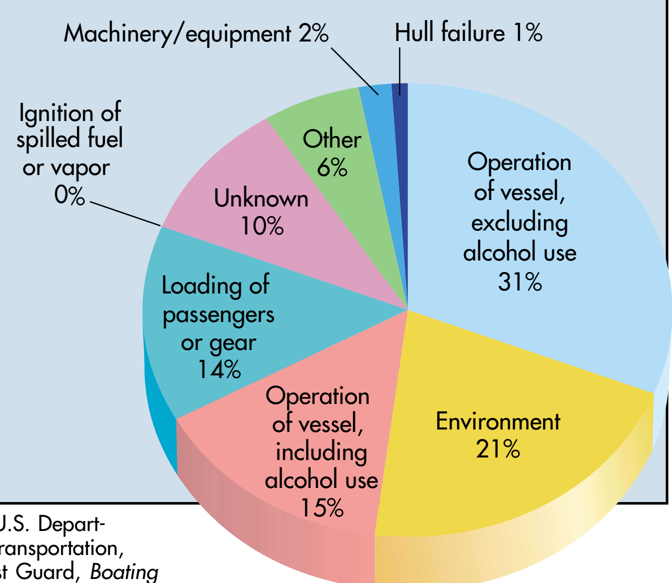
Number of Recreational Boats: 1975-98



Source: U.S. Department of Transportation, U.S. Coast Guard, *Boating Statistics* (Washington, DC: Annual issues).

Figure 3-43

Recreational Boating Fatalities, by Cause: 1998



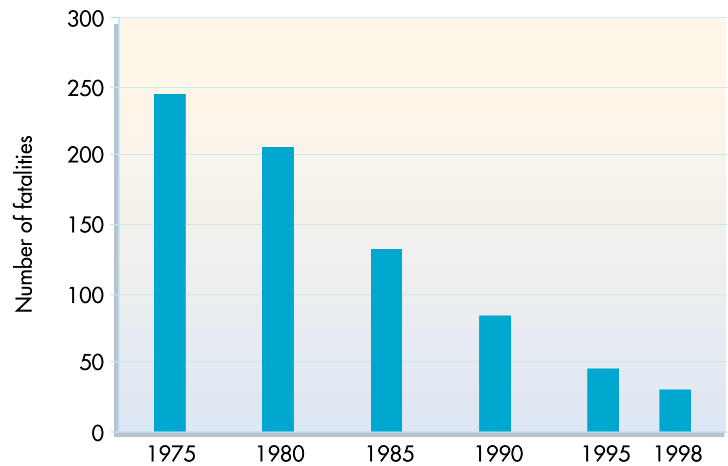
Source: U.S. Department of Transportation, U.S. Coast Guard, *Boating Statistics* (Washington DC: 1998).

Commercial Vessel Operations: In 1975, safety was a growing concern as 243 commercial maritime industry fatalities were recorded (figure 3-44). In the 1970s, new navigation safety regulations became effective, and the USCG began to focus on ensuring compliance by thousands of foreign vessels entering U.S. waters. Federal research and development centered on ship control, navigation, and communication as a means of improving vessel operations and enhancing safety.

Since then, much of the maritime transportation industry has implemented electronic shipboard controls for better navigation, communications, and maneuvering. Computer-based systems for steering and machinery monitoring, along with antistranding sonar systems to prevent vessel groundings also have improved ship safety. Through the Internet, mariners receive notices about potentially hazardous situations on a real-time basis.

Figure 3-44

Fatalities Involving Commercial Waterborne Transportation: 1975-98



Source: U.S. Department of Transportation, U.S. Coast Guard, Office of Investigation and Analysis, Compliance Analysis Division (Washington, DC: Various years).

Continued emphasis on vessel inspections as well as on improvement of design and equipment requirements combined with new vessel-tracking technology, worldwide digital communications, and integrated navigation systems using electronic charting have allowed the commercial maritime transportation system to attain high levels of safety. As the number of marine casualties has dropped, so has the number of fatalities. The principle focus of marine safety efforts is now on human error, a primary causal factor in four out of five marine accidents.

Prevention Through People (PTP), a USCG initiative, attempts to reduce the human factors problem through education and training programs, as well as by publishing and broadcasting information for mariners on weather, waterway depth, changes to navigation markers, and hazards to navigation. In 1995, to further reduce the human factors problem in maritime incidents, the world's maritime community reached an agreement on new standards and certifications for training and educating mariners, which is now being implemented.

Passenger Vessels: The U.S. domestic passenger vessel fleet consists of approximately 6,200 vessels, of which approximately 98 percent are small passenger vessels (e.g., charter fishing, harbor tour, or dinner cruise boats) or ferries. Passenger vessels in the domestic fleet carry approximately 200 million passengers annually. Ferry vessels carry 134 million of these passengers. There are approximately 130 foreign-flag passenger vessels that operate from U.S. ports. These vessels carried almost 5.5 million passengers on cruises in 1998 [USDOT 1999]. The USCG enforces applicable domestic and international safety standards on the U.S. domestic passenger vessel fleet and international safety standards on foreign-flag passenger vessels operating out of U.S. ports. The aggressive USCG examination program of these vessels has resulted in no passenger deaths on a foreign-flag vessels operating from U.S. ports since 1984, and the death rate involving the U.S. domestic passenger vessel fleet continues to decline.

"Based on careful analysis, the Coast Guard has focused its safety efforts toward the source of most accidents: human error. The Prevention Through People program has created partnerships throughout industry that have significantly reduced the number of maritime accidents—without additional regulations."

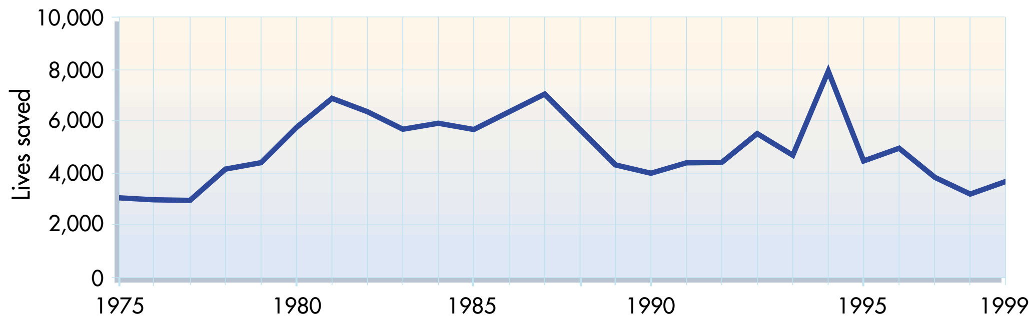
Adm. James M. Loy
Commandant,
U.S. Coast Guard

Today, technological advances have made passenger vessels safer, but they also have increased the complexity of vessel operation and maintenance. Newer vessels, which often have much higher passenger capacities than previous vessels, have increased the number of possible casualties in the unlikely case of a catastrophic event. Passenger-vessel traffic is increasing rapidly due to the growing markets for cruise ships, gambling ships, and passenger ferries; and the number of high-speed, high-capacity passenger vessels is also growing. Such increases can offset technological safety advances as the opportunity for human error, resulting in collisions and/or vessels running aground, increases.

Search and Rescue: Over the past quarter century, the USCG has rescued more than 3,000 boaters, fishermen, divers, and swimmers each year—or more than eight a day—from the nation's oceans, rivers, lakes, and bays (figure 3-45). Figure 3-46 shows the number of lives saved and lost in search and rescue missions in various USCG districts.

Figure 3-45

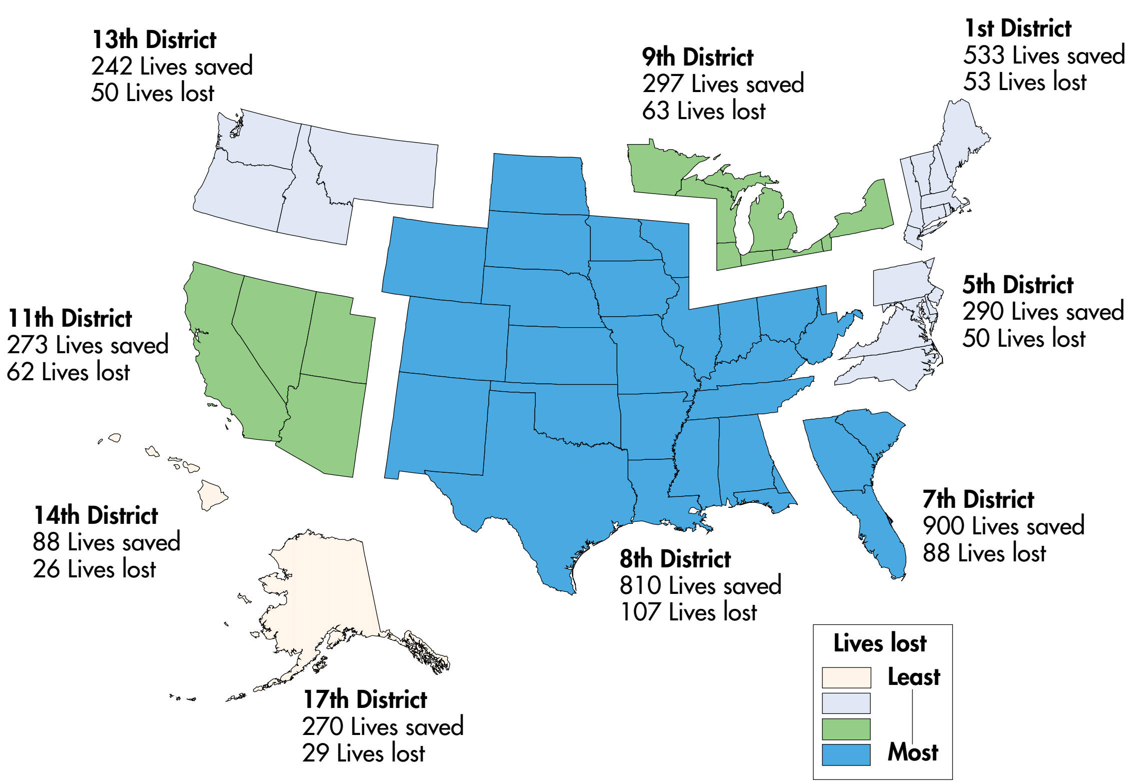
Lives Saved in Search and Rescue Missions: 1975-99 (Annual totals)



Source: U.S. Department of Transportation, U.S. Coast Guard, *Search and Rescue Summary Statistics* (Washington, DC: Annual issues).

Figure 3-46

U.S. Coast Guard Districts and the Number of Lives Lost and Saved: 1999



Source: U.S. Department of Transportation, U.S. Coast

In addition to search and rescue activities in U.S. waters, the USCG, under international agreement, is responsible for search and rescue activities in about 50 percent of the North Atlantic Ocean and more than 75 percent of the North Pacific Ocean, an area covering more than 28 million square nautical miles [USDOT USCG 2000d]. The USCG's search and rescue system—a high-impact, highly computerized structure—consists of multimission shore stations, 23 cutters, 1,400 small boats, and more than 200 aircraft, all linked by communications networks [USDOT USCG 2000a]. More than 10 percent of the USCG's operational hours for aircraft, cutters, and boats are devoted to search and rescue.

Distress calls: Over the last 25 years, the world's maritime system emerged from dependence on 19th century telegraph code to send distress signals, to modern communications technology—the Global Maritime Distress and Safety System (GMDSS).

Distress calls using Morse code (the familiar S-O-S) have saved thousands of lives, but its use required skilled radio operators spending many hours monitoring the radio distress frequency, and its range was limited. In 1988, the International Maritime Organization set a February 1, 1999, deadline for ships to complete installation of GMDSS technology. U.S. ships were compelled to comply by the Telecommunications Act of 1996, which set GMDSS as the new standard.

This new system is based on a combination of satellite and terrestrial radio services and has changed international distress communications from being primarily ship-to-ship based to ship-to-shore Rescue Coordination Center based. Now used almost universally, GMDSS can reliably determine a vessel's position, home in on its exact location, broadcast maritime safety information, and provide general and ship-to-ship communications.

Keys to the Future

Recreational Boating: In the next quarter century, the number of recreational boaters is expected to increase by more than 65 percent to more than 130 million annually [Loy 1999]. The success of safety efforts will depend on the effectiveness of many education and enforcement programs that focus on seamanship and the use of life jackets. The Coast Guard estimates that the use of life jackets might have saved more than 500 drowning victims in 1998 alone [USDOT BTS, MARAD, and USCG 1999].

Increases in recreational and commercial traffic (particularly barge traffic) on shared waters pose a growing threat to recreational boaters, mariners, and the environment. Each year, 800 million short tons of U.S. domestic trade (approximately 75 percent of all domestic trade) is carried aboard barges that are either towed or pushed by tugs through our coastal and inland waters [USACE]. All boaters should be aware of the location of shipping channels, anchorages, commercial piers, draw bridges, and other congested port areas and should understand that tugs, barges, and any large commercial vessels have limited ability to steer clear of collisions or stop. In 2000, the USCG is proposing regulations that would create four sets of safety measures for towing vessels and tank barges operating in northeast waters:

1. positive control for barges,
2. enhanced communications,
3. voyage planning, and
4. areas of restricted navigation.

Commercial Vessel Operations: Growth in intermodal cargo movement using larger ships—and projected continued growth—presents a new safety challenge. Since 1975, a new generation of high-capacity container ships has emerged with double- and triple-container capacity. These new, bigger ships use radar-based Vessel Traffic Systems, navigational aids, and automated identification systems for better ship-to-shore and ship-to-ship communications to enter and leave ports safely. The new technologies allow minimal crews—as few as two—creating new challenges should these large vessels founder.

Maritime workers have a high fatality rate, and fishermen top the list. Dwindling fishery stocks, increased competition, and limited fishing seasons have increased risk-taking by fishermen. This risk-taking is compounded by the fact that fishing vessels have relatively few safety standards imposed by law or regulation. The number of fishing vessels of different sizes that operate in different locations and climates makes development of universal safety regulations difficult. The USCG has recently begun implementing a safety program aimed at the fishing industry [USDOT USCG 1999]. Its long-term recommendations include safety examinations, inspections, and operator licensing; vessel safety and stability standards; coordination of fisheries stock management with safety; and improvement of casualty investigation data. Efforts to focus on safety awareness to reduce human errors need to be combined with enforcement.

Passenger Vessels: Cruise ships are expected to attract 6.5 million passengers by 2002; and because there are only two U.S.-flag cruise ships, most of these passengers will be sailing on foreign-flag vessels [USDOC ITA 2000]. U.S. safety regulations do not always apply to foreign vessels, especially outside of U.S. waters, prompting safety concerns for Americans traveling on vessels over which the United States may have limited jurisdiction. The increased passenger capacity of cruise ships has raised questions regarding the adequacy of international passenger vessel safety requirements. These requirements will need to be evaluated to ensure the continued safety of cruise ships operating out of U.S. ports.

As conventional land transportation arteries grow more congested, ferry passenger transport is attracting renewed attention, particularly interest in fast ferries. Even though overall ferry traffic has declined slightly in recent years, fast-ferry operations have experienced some growth. From 1993 to 1997, fast-ferry passenger traffic increased at a rate of 6.8 percent per year [USDOT MARAD 1999]. The USCG's focus on targeting human errors (through domestic and international programs) as a means to reduce accidents and fatalities, likely will result in specific safety oversight of high-speed ferries and other technologically advanced vessels.

Safety Advances: Ships are required to receive broadcasts of maritime safety information, which may prevent some maritime disasters from taking place, while enhancing rescue operations for those that do occur. By 2005, the USCG will have a new generation of technology that will eliminate more than 65 existing coverage gaps and reduce search times—in essence, taking the search out of search and rescue—increasing the probability of successful rescues [USDOT USCG 2000b]. If the 2005 target is reached, then by 2025 advances in technology will completely eliminate coverage gaps and rescuing efforts will be highly successful.

Pipeline Safety

As urban sprawl has encroached deeper into surrounding land over the past 25 years, risks posed by the nation's network of nearly 2 million miles of pipelines and their impact on the environment has become a major public concern [USDOT RSPA 2000c]. Two pipeline incidents during the past two years have raised further public concerns: the Bellingham, Washington, incident in June 1999 and the Carlsbad, New Mexico, incident in August 2000. In April 2000, the Secretary of Transportation proposed new legislation that would require: a) internal inspection, pressure testing, or other best achievable technology performed on a periodic basis; b) clearly defined criteria for analyzing the inspection of testing and the repair of any problems found; c) measures (e.g., emergency flow-restricting devices or leak detection) that prevent and mitigate the consequences of a leak; and d) providing the public and local communities with access to the information they need to ensure their protection from potential pipeline accidents. The proposed legislation includes provisions for expanded partnerships with state regulatory agencies, improved collection of safety and accident data, and tougher penalties for operators found to violate safety regulations. In November 2000, the USDOT issued strong new requirements for large hazardous liquid pipeline operators to regularly inspect and promptly repair pipelines in populated and environmentally sensitive areas and to take systematic steps to detect and prevent leaks. Also, the USDOT is taking steps to implement stronger pipeline safety standards, including improved enforcement, enhanced federal-state partnerships, increased public access to information, and more innovative technology. Together, these actions will help ensure that our oil and gas pipeline system is sound, our communities safe, and our environment protected.

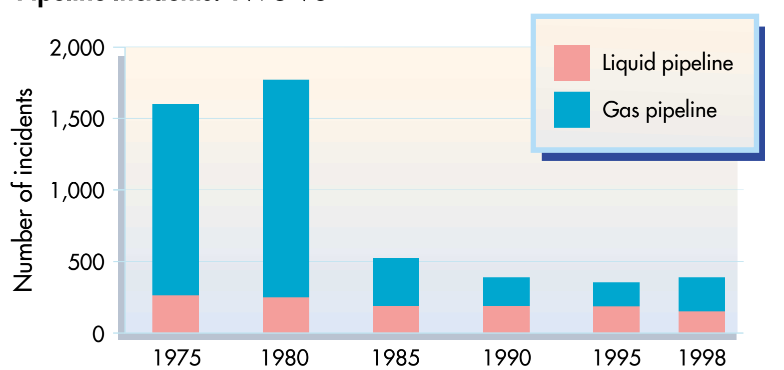
In 1975, 16 people were killed and 208 were injured in almost 1,700 pipeline incidents. During that decade, excavation damage was estimated to cause more than half of all pipeline incidents [NTSB 1998]. Other major causes of pipeline incidents included material failure and corrosion. Of particular concern were the many low-pressure natural gas distribution lines in towns and cities that were made of century-old, uncoated cast iron that was increasingly subject to failure.

During the era of pipeline construction, the industry was governed mostly by voluntary standards. But, by 1975, the USDOT had issued regulations covering pipeline design, construction, operation, and maintenance for both natural gas and interstate hazardous-liquid pipelines.

Today, there are far fewer pipeline incidents. These incidents dropped nearly 80 percent from 1975 through 1998 (figure 3-47), and the loss of product due to accidental ruptures has been cut by more than half [USDOT RSPA 2000c]. However, the number of fatalities associated with pipeline incidents has generally risen (figure 3-48).

Figure 3-47

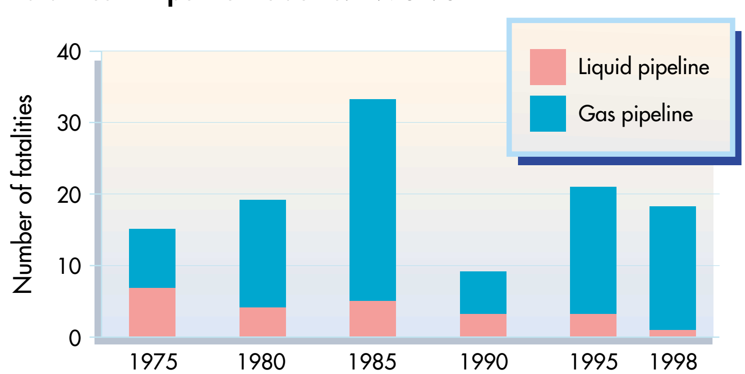
Pipeline Incidents: 1975-98



Source: U.S. Department of Transportation, Research and Special Programs Administration, Office of Pipeline Safety, personal communication, 1999, available at http://ops.dot.gov/stats.htm.

Figure 3-48

Fatalities in Pipeline Incidents: 1975-98



Source: U.S. Department of Transportation, Research and Special Programs Administration, Office of Pipeline Safety, personal communication, 1999, available at http://ops.dot.gov/stats.htm.

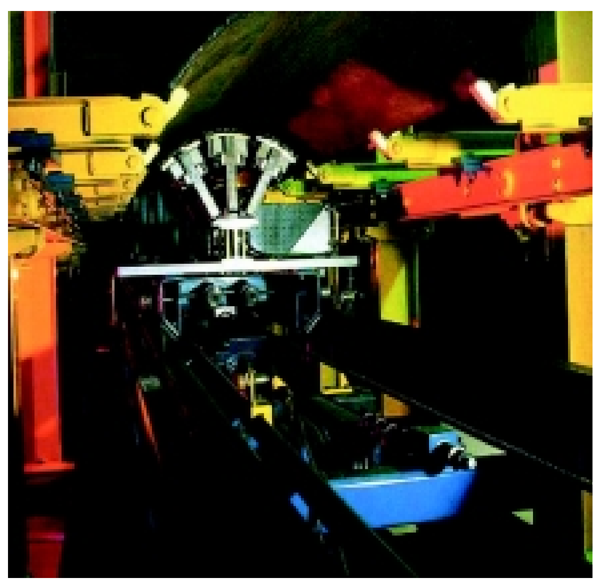
Outside force damage, usually from excavation, still is the leading cause of pipeline failures, averaging 39 percent of the total, followed by corrosion with an average of 20 percent [USDOT RSPA 2000c]. Other causes of failure are incorrect operation, construction, or material defect; equipment malfunction; and failed pipe. To reduce the problem of excavation damage, one-call notification centers have been established in 48 states and the District of Columbia [NTSB 1998]. Efforts are underway by the Research and Special Programs Administration (RSPA), state officials, and industry to raise awareness of the one-call centers in order to lower the number of incidents caused by excavation.

Major advances in the materials used for pipes and welding, inspections, and the installation process over the past 25 years have reduced the number of leaks and made those that take place less severe. New corrosion coatings and new application processes have produced dramatically longer lives for pipes.

Computer technology—Supervisory Control and Data Acquisition systems—continuously provides today's dispatchers with temperature, pressure, and flow rates along many pipelines. This information is vital for the daily operation of these pipelines and can help pinpoint potential and real problems as they occur.

Keys to the Future

The conflict between expanding residential communities and pipeline operations is likely to increase as the U.S. population continues to grow and metropolitan areas expand into the rural areas where pipelines are predominately located. The consequential crowding of pipelines will increase the need to identify sensitive locations in high-density population areas (which may need special attention in the unlikely event of an incident) and to prevent damage due to excavation.



Battelle

Smart pigs ensure pipeline safety by using magnetic or ultrasonic scanning to inspect the internal and external walls of a pipeline. They can be used to inspect pipe sections, as shown, or they can be inserted in to existing pipelines where they are moved by the flowing material, avoiding the need for excavating or flow stoppage to inspect pipelines.

A multiagency effort, the geographic information system-based National Pipeline Mapping System will help pinpoint where pipelines are located, providing an analytical tool to mitigate risks to environmentally sensitive and populated areas and will help educate the public about the risks of pipelines in their communities. Efforts are underway now to define the data, which will result in better information for identifying safety trends, targeting where problems are most likely to occur, and monitoring how well applied solutions are working. Further technological advances will be used to improve pipeline safety. Industry will be equipped with advanced computer control systems that monitor pipeline integrity and deliver pipeline products more efficiently. New improvements in aerial leak detection technology will complement these efforts.

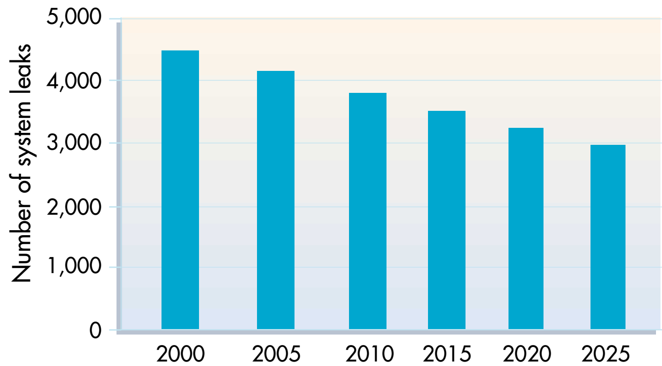
A technology known as "smart pigs" promises to be the primary inspection tool for pipelines well into the 21st century [USDOT RSPA 2000c]. Smart pigs have been used for at least 10 years, and their use and their capabilities are growing. Smart pigs will be increasingly used to detect a variety of pipeline integrity concerns such as pipe wall thinning, excavation hits to pipelines or other mechanical damage, material defects, and cracks. Efforts in the area of acoustical monitoring will provide real-time detection of excavation-related damage. Complementary to these efforts, in the future, Global Positioning System (GPS) technology will work with smart pig technology to accurately map pipelines and pinpoint potential problems so they may be corrected before incidents occur [Wilke 1998]. A longer range effort is underway to develop a single smart pig that can detect corrosion and mechanical defects.

Smart pigs are effective for about 90 percent of hazardous liquid pipelines, but they have more limited use on natural gas pipelines because these pipelines tend to have interconnected pipe segments of varying diameters. Alternative inspection technologies will be needed for pipelines that cannot accommodate smart pigs due to varying pipe sizes and configurations.

Based on historical trends, we anticipate an 8 percent reduction every five years in the number of reported natural gas transmission system leaks through the year 2025, as the chart depicts (figure 3-49), or an overall reduction of about 36 percent in the number of system leaks from the year 2000 through the year 2025.

Figure 3-49

Natural Gas Transmission Pipeline System Leaks



Source: U.S. Department of Transportation, Research and Special Programs Administration, personal communication December 5, 2000.

Box 3-13

Smart Pigs

Smart pigs—computerized magnetic or ultrasonic mechanical devices that are pushed along by flowing material inside the pipeline—inspect internal and external pipe wall conditions and the thickness of the metal wall. They allow pipeline operators to inspect for damage without excavating the pipe or stopping product flow.

Types of pigs:

- Magnetic flux leakage pigs detect pipe wall thinning or loss of material, which usually means corrosion. Under certain conditions, they can detect some types of mechanical damage, such as gouges, but cannot characterize or size mechanical damage to determine its severity. They can be used in both gas and hazardous-liquid pipelines and have been available since the mid-1960s.

continued next page

Box 3-13 continued

- Ultrasonic pigs detect corrosion and cracks in the pipe wall. They also can detect mechanical damage, although they cannot determine the severity of the damage with a high level of confidence. These devices require a liquid film between the ultrasonic transducer and the pipe wall. Therefore, they can be used only in liquid pipelines.

- Elastic wave pigs detect cracks, stress corrosion cracking, external coating faults, and other axially oriented pipe defects. The ultrasonic transducers used in elastic wave tools have rolling contact with the pipe wall. They do not require a liquid film and can be used in gas pipelines as well as in hazardous-liquid pipelines.

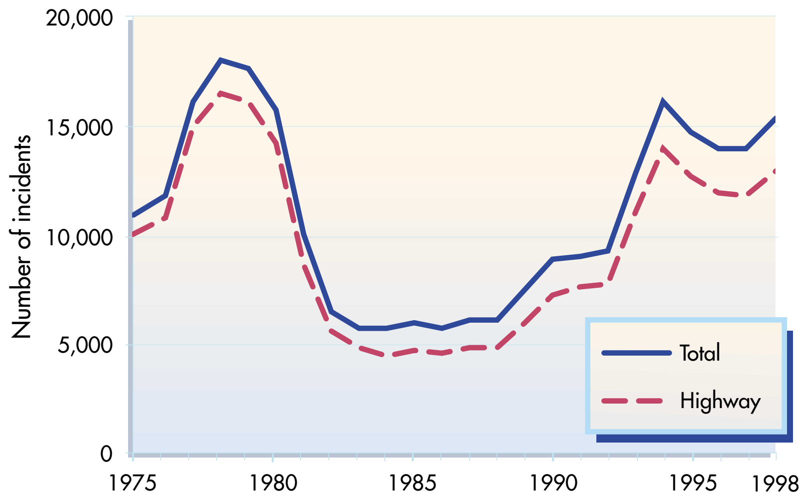
- Geometry pigs detect changes in the internal size of new and operating pipelines. Ovality, dents, and buckles can be detected in both gas and hazardous-liquid pipelines.

- Camera pigs allow visual inspection of the inside bottom quadrant of gas pipelines by producing photographs of the inside surface.

- Pipe-curvature pigs determine position, orientation, curvature, ovality, dents, and wrinkles in gas pipelines and those that transport liquids. These devices can detect pipe movement after seismic events.

Figure 3-50

Reported Hazardous Materials Incidents: 1975-98
(Annual totals)



Source: U.S. Department of Transportation, Research and Special Programs Administration, Office of Hazardous Material Safety, Hazardous Materials Information System (Washington, DC: 1999).

Hazardous Materials Safety

Over the last 25 years, the transportation of hazardous materials (hazmat) has been the subject of increased scrutiny. Today, an estimated 800,000 U.S. hazmat shipments are made daily [USDOT RSPA 1998]. These shipments, in combination with a growing population, urban sprawl, and increasing air-, road-, rail-, and water-traffic congestion, fuel concern for the safe transportation of hazardous materials and the potential consequences of a catastrophic event.

The Hazardous Materials Transportation Act of 1974, signed into law in 1975, gave the USDOT expanded power to regulate hazmat transportation. The USDOT has the authority to determine which materials pose unreasonable transportation risks to public health and safety.

Regulations are issued by the USDOT covering training, packaging, hazard communication, operations, enforcement, emergency response, and incident reporting.

In 1975, more than 15 million barrels of petroleum products, the largest single component of transported hazmat, were being shipped daily across the country [USDOE 1997], as were hundreds of thousands of tons of hazardous chemicals [Maio & Liu 1987]. Most hazmat tonnage was carried by rail, water, and pipeline modes, but highway transport—accelerated by growth of the Interstate Highway System—resulted in the greatest number of individual shipments. Most hazardous materials incidents, defined as any unintentional release of material (or evacuation based on potential release), took place on highways (figure 3-49).

Hazmat safety regulation has undergone profound change since 1975, sparked by several major events, including the 1984 toxic gas release in Bhopal, India. That incident resulted in approximately 3,800 deaths and prompted a new subclass of hazardous materials—those that are classified as poisonous by inhalation. The Bhopal incident also led to passage of the 1986 Emergency Planning and Community Right-to-Know Act, which gave local communities a greater ability to learn what hazardous materials were being stored in their communities. Moreover, the incident catalyzed emergency response planning efforts at the federal, state, and local levels.

In 1990, the Hazardous Materials Transportation Uniform Safety Act required certain hazmat shippers and carriers to pay a fee to register with the USDOT. According to RSPA, changes in the registration and fee assessment program, authorized in the 1990 Act, have provided a projected 50 percent increase in funding, as expanded registration requirements swelled the number of registered hazmat shippers and carriers from about 27,000 to 45,000. This money has been used to fund emergency planning and training grants with enhanced capabilities for identifying, controlling, and responding to risks posed by hazmat shipments. This registration program also created a funding mechanism for federal grants to support local hazmat safety planning and training. Since 1993, these grants have provided training to about 815,000 people who respond to hazardous materials incidents [USDOT RSPA 2000a].

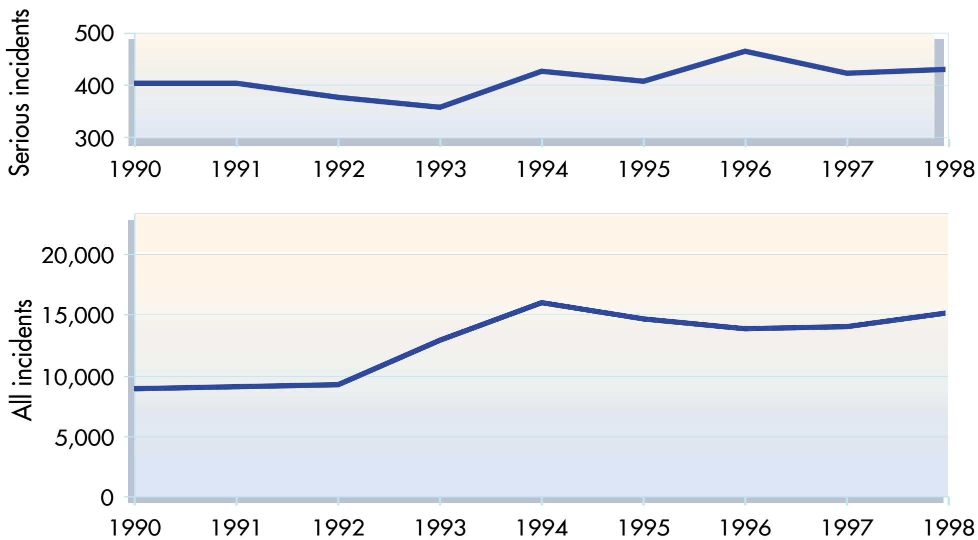
The May 1996 ValuJet crash, resulting in 110 deaths, again heightened public awareness of hazmat transport risks. Improperly marked and stowed chemical oxygen generators aboard the flight triggered intense heat in an inaccessible cargo bay, causing a rapid fire, smoke, and loss of aircraft control. Chemical oxygen generators were subsequently banned as freight aboard any passenger aircraft. If transported on cargo aircraft, such materials must be shipped in an inaccessible compartment that is required to have smoke and fire detection and suppression systems. Empty oxygen generators were banned from all aircraft, both cargo and passenger.

Although the number of hazmat incidents reported annually to USDOT is growing due to long-term traffic growth and better reporting compliance, the level of *serious* incidents has remained nearly constant (figure 3-51). Serious incidents are defined as one involving a fatality or major injury due to a hazardous material; closure of a major transportation artery or facility or evacuation of six or more people due to the presence of hazardous material; or a vehicle accident or derailment resulting in the release of hazardous material.

Efforts to improve data collection, management, and allocation of USDOT resources are also underway. Efforts by the Bureau of Transportation Statistics (BTS) are yielding much greater detail about nationwide hazardous materials flows, as well as better hazmat vehicle use information, and the modal distribution of hazardous materials (table 3-5).

Figure 3-51

Serious Hazardous Materials Incidents and All Hazardous Materials Incidents: 1990-98 (Annual totals)



Source: U.S. Department of Transportation, Research and Special Programs Administration, Office of Hazardous Materials Safety, Hazardous Materials Information System, 1999.

Table 3-5

Hazardous Materials Shipment Characteristics by Mode of Transportation for the United States: 1997

Mode of transportation	Ton-miles Number	Ton-miles Percent
All modes	263,809	100.0
Single modes	258,912	98.1
Truck	74,939	28.4
For-hire truck	45,234	17.1
Private truck	28,847	10.9
Rail	74,711	28.3
Water	68,212	25.9
Air (including truck and air)	95	0.04
Pipeline	n/a	–
Multiple modes	3,061	1.2
Parcel, U.S. Postal Service or courier	78	–
Other multiple modes	2,982	1.1
Other and unknown modes	1,837	0.7

Source: U.S. Department of Transportation, Bureau of Transportation Statistics, 1997 Commodity Flow Survey data; U.S. Department of Commerce, Census Bureau, *1997 Commodity Flow Survey, Hazardous Materials,* EC97TCF-US(HM) (Washington, DC: 1999).

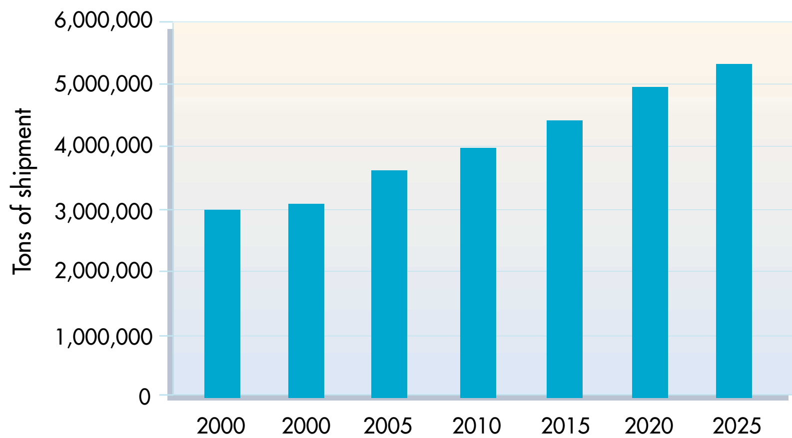
Keys to the Future

A number of current trends will continue to shape how the USDOT fulfills its hazardous materials mandate over the next 25 years. Hazmat shipment growth, continued globalization of trade, changes in the workforce, and improvements in materials technology and IT/ telecommunications applications are among these.

The number of U.S. hazmat shipments is expected to grow from about 1 million daily to well over 1.5 million per day. In terms of tonnage, the annual volume of hazardous materials transported for commerce in the United States is forecast to reach 5.7 billion tons by 2025. Using the 1996 baseline figures of 3.2 tons of hazardous materials shipments, the Chemical Manufacturers Association projects that aggregate hazmat shipments will grow at roughly at 2 percent per year (figure 3-52).

Figure 3-52

Actual and Forecast Hazardous Materials Shipments



Source: U.S. Department of Transportation, Research and Special Programs Administration, personal communication, December 5, 2000.

Curbs in fossil fuel use may slow growth in the shipment of petroleum products, the largest component of hazmat traffic. However, an expanding economy will pressure growth, and continued changes in chemical and biological technology present an ever-increasing list of products with which the government and the shipping community must be familiar.

By 2025 the modal share of hazmat transportation will change as well. By one set of forecasts (the DRI/McGraw Hill) air and intermodal shipments are expected to gain an increasingly significant share of the hazmat market. As high value-added chemical products gain market share and demand for time-definite delivery grows, hazmat is more likely to be shipped by air and truck modes.

- Over the next 25-year period, air and intermodal movements are likely to double the current growth rates to meet the increasing demand in the high value-added segments of the chemical industry. Small-package and on-bulk containers will also grow at a rapid rate.

- The shift to the air and truck modes will be balanced by a slight decline in the share of water and pipeline transportation of hazmat. Rail is forecast to maintain its market share of about 6 percent. Truckload/LTL highway transportation is anticipated to gain market share of moving chemical products. For moving petroleum, trucks are also forecast to continue to increase their market share.

Radioactive shipments, considered to be specialized hazmat traffic, will remain about 1 percent of total annual shipments. Although these shipments are a small proportion of the traffic, they still may pose increased safety challenges. Ongoing legislative efforts to establish a permanent spent fuel waste repository in the United States could increase the number of spent fuel shipments as much as fourfold annually by the year 2025, from 100 to more than 400 shipments. Combined with transport and burial of other nuclear wastes at the Waste Isolation Pilot Project site in New Mexico, an increased number of highly radioactive shipments will traverse the U.S. rail, highway and, to a lesser extent, waterway networks.

Along with growth in the U.S. economy and its hazmat traffic base, continued globalization of trade will pose additional safety challenges. Not only are export and import trade shipments expected to grow in number, but the complexity of that traffic will grow as well. Differing hazmat regulations, safety policies, and technological proficiencies will present continuing challenges to ensuring the safety of global hazmat traffic. Current efforts to harmonize U.S. hazmat regulations with internationally endorsed practices must keep pace with the safety demands placed on the transportation network.

As changes in the workforce continue, the need for education and training in the hazmat community will also increase. The U.S. transportation system, including the hazmat sector, will be characterized by an aging population and higher levels of turnover among employees. Coupled with higher demand for hazmat shipments and, consequently, increased technical knowledge, there will be an acute need for education and training of hazmat employees by the year 2025. As underscored in the 1996 Valuejet accident, the need for shipper and air carrier personnel to be knowledgeable about the USDOT's hazardous materials regulations will be critical.

Technology will play a vital role in future hazmat transportation. Offsetting continued development of new hazardous materials and growth in their traffic will be improvements in materials technology. Stronger, more durable materials will make the packaging—for example, boxes, canisters, barrels, containers, and tank cars—more resistant to damage during normal handling and transport, and even under accident conditions. Other technology advances may also help prevent hazmat incidents from occurring in the first place. Computer software, for example, may improve the ability to translate shipping papers, packaging labels, and other documentation and communication media into other languages or into a single, common trading language.

For monitoring hazmat traffic and managing incidents when they do occur, improved information and telecommunications technology will be critical. Tracking sensitive cargos will be easier and more affordable as various global satellite systems become operational and as wireless handsets become increasingly "connected" to the Internet. Similarly, wireless telecommunications and other information technology advances will improve the ability of emergency response personnel to manage events at hazardous materials accident sites.

Challenges to the USDOT's ability to manage hazmat traffic and trade will grow as globalization increases. Helping to meet these challenges will be continued improvements in hazmat education and training, aided by a confluence of technology improvements and deployment.

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